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REVIEW ASSESSMENT REPORT. ELECTRON/PROTON
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DESIGN CERTIFICATION REVIEW ASSESSMENT REPORT

ELECTRON/PROTON SPECTROMETER

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DESIGN CERTIFICATION REVIEW ASSESSMENT REPORT
ELECTRON/PROTON SPECTROMETER

EPS-841

Details of illustrations in
this document may be better
studied on microfiche

Design & Built by
Lockheed Electronics Company
Houston, Texas

NASA/MSC Project Management by
E&D/ISD

INTRODUCTION

The Electron-Proton Spectrometer (EPS) is being developed for the NASA Skylab Program by Lockheed Electronics Company, Houston, Texas under Contract NAS 9-11373.

The EPS is mounted external to the Skylab module complex on the Command Service Module. It is designed to make a 2π omni-directional measurement of electrons and protons which result from solar flares or enhancement of the radiation belts. The EPS data will provide accurate radiation dose information so that uncertain Relative Biological Effectiveness (RBE) factors are eliminated by measuring the external particle spectra. Astronaut Radiation Safety, therefore, can be ensured, as the EPS data can be used to correct or qualify radiation dose measurements recorded by other radiation measuring instrumentation within the Skylab module complex.

The EPS has the capability of measuring an extremely wide dynamic radiation dose rate range, approaching 10^7 , to an accuracy generally limited by statistical fluctuations, thereby making it applicable to long missions of low average dose rates. Simultaneously the EPS has the capability to process data from extremely high radiation fields such as might be encountered in the wake of an intense solar flare.

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DOCUMENTATION LIST

Nomenclature

Number

Vibration Testing of the EPS
Structural Test Unit.

EPS-361

EPS Thermal Test Unit, Thermal/
Vacuum Test

EPS-518

Shock Test of EPS Structural
Test Unit

EPS-359

Test Report EPS Qualification
Test Unit Qualification Test

EPS-695

Verification Plan for EPS

EPS-435

EPS Summary for Critical Design
Review

EPS-473

EPS for Skylab Technical Design
Review

EPS-221

End Item Spec.

Addendum to NAS9-11373

ICD's

Electrical

MH04-02119-234

Envelope

MH04-02118-134

Environmental

MH04-02120-434

Ground

MH04-02121-434

EMI

MH04-02057-234

1.0 FUNCTIONAL REQUIREMENTS

1.1 Requirement

Provide data from which electron and proton spectra can be determined

- o 4 electron channels in range 0.5 Mev to 4 Mev
- o 6 proton channels in range 10 Mev to 120 Mev
- o Viewing angle 2π steradians

Data will be used in conjunction with the following radiation instrumentation to determine radiation dose:

Personal Radiation Dosimeter

Radiation Survey Meter

Van Allen Belt Dosimeter

2.0 DESIGN APPROACH

DESIGN APPROACH

The approach to the end item design was to:

1. Utilize the design of an existing spectrometer. (Flown in South Atlantic Anomaly Probe).
2. Determine spacecraft location as shown in figure 2-1.
3. Determine spacecraft interfaces:
 - Electrical
 - Mechanical
 - Environmental
 - Electronic (figure 2-2)
4. Anticipation of proton and electron spectra at the Skylab orbit of 235 nautical miles. These spectra are shown in figures 2-3 and 2-4.

Utilizing the information obtained from these requirements major subassemblies were developed to cover each category.

To meet the counting rate requirements extensive designing was required to provide low impedance signal return paths for all electronic circuits.

A modular concept which would provide for individual subsystem testing was established. In addition it was decided to utilize welded cordwood construction

INSTALLED IN SM IN
SECTOR NO. 3 FAIRING AREA,
BY RADIAL BEAM NO. 2.

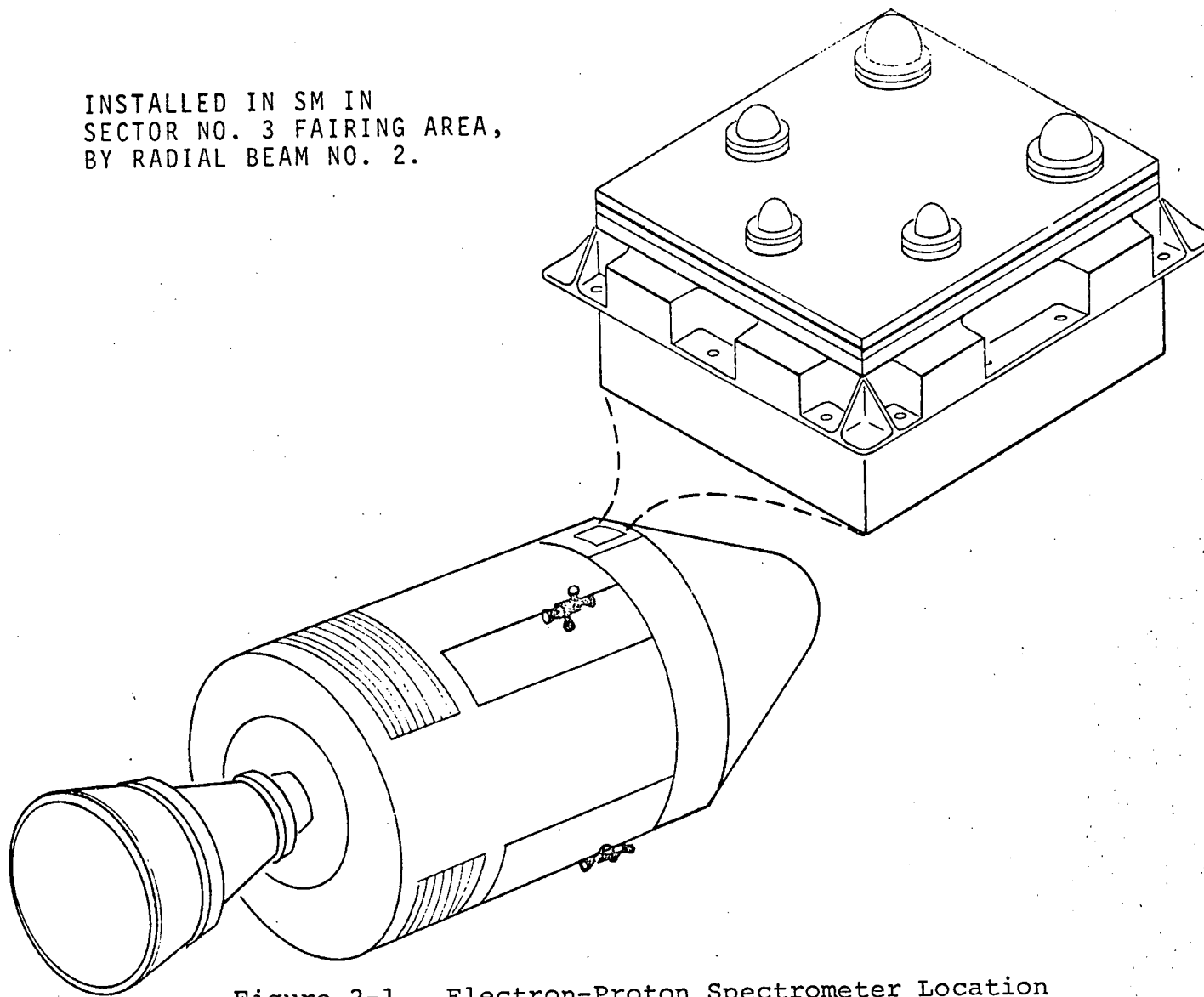


Figure 2-1. Electron-Proton Spectrometer Location

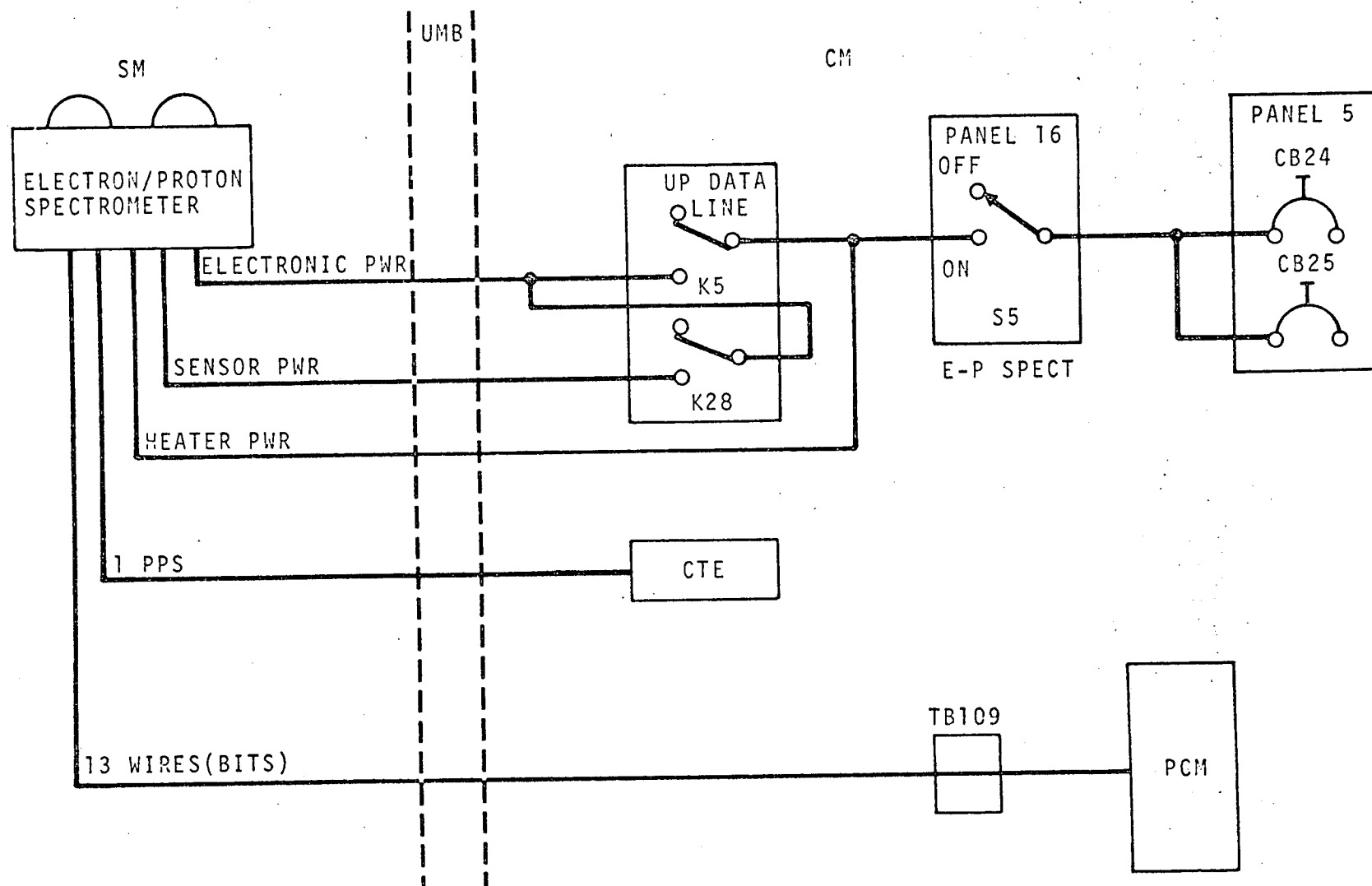


Figure 2-2. Electronic Interface

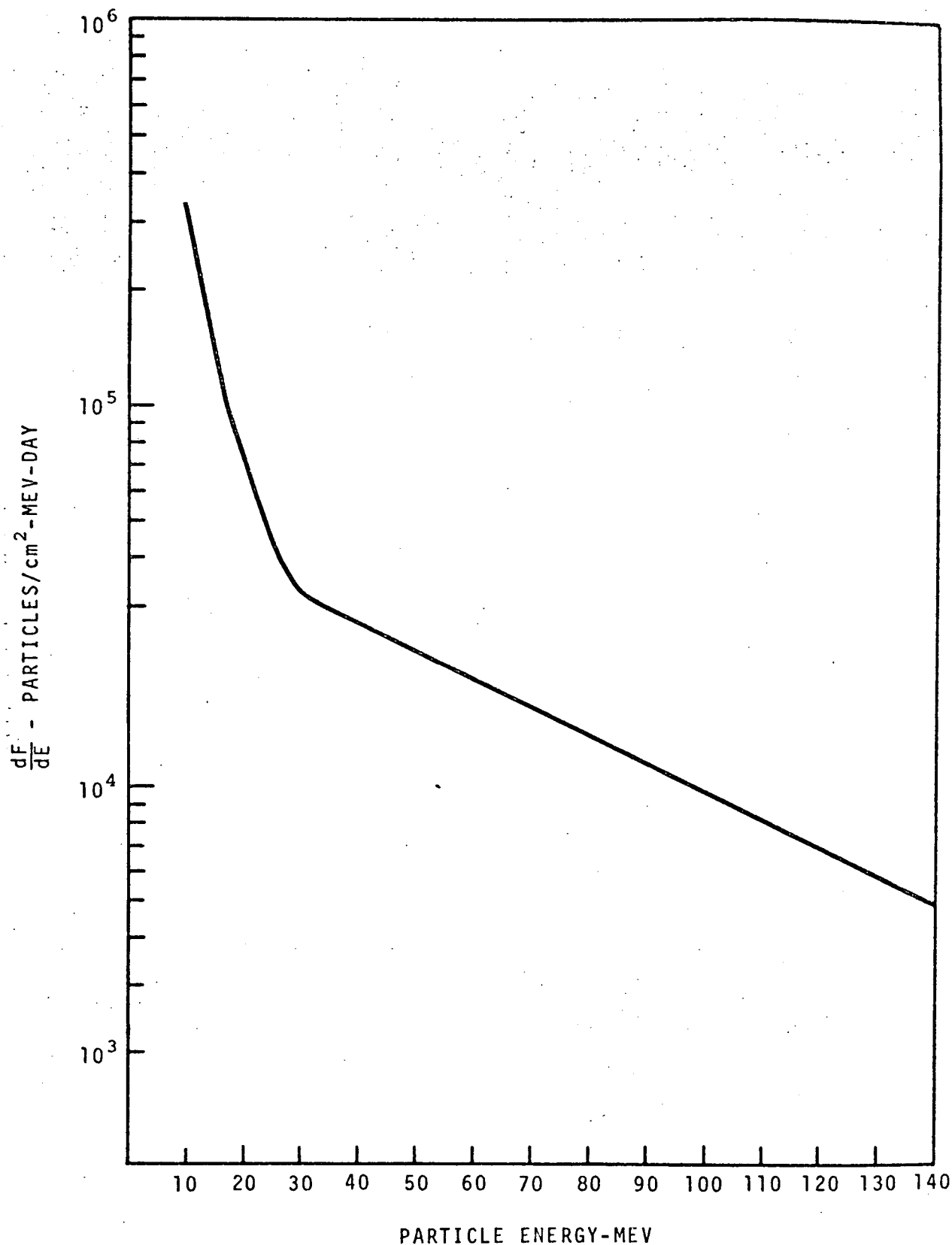


Figure 2-3. Differential Proton Flux
at 235 Nautical Miles

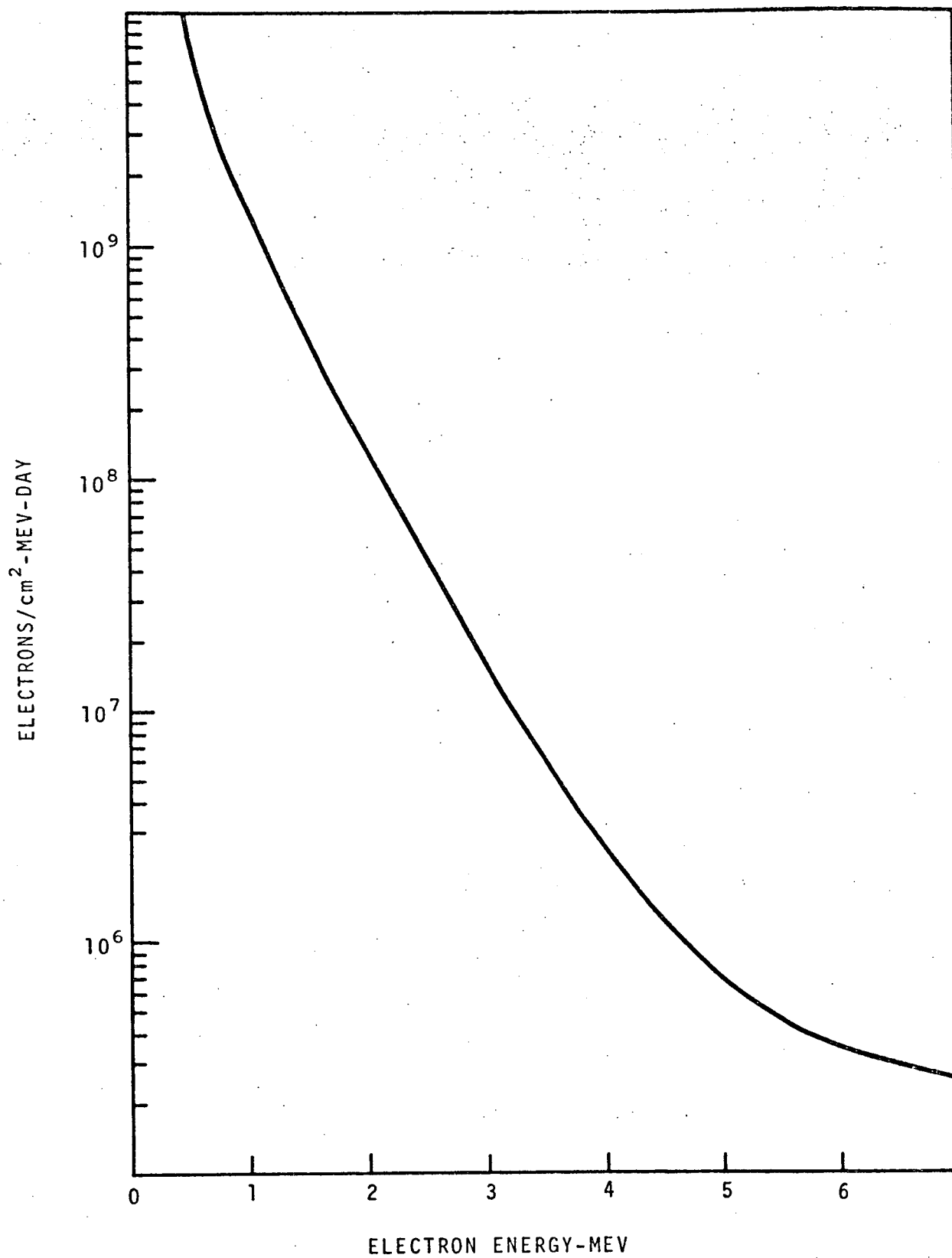


Figure 2-4. Differential Electron Flux
at 235 Nautical Miles

DESIGN APPROACH (Continued)

especially in the data processor. Those circuits using soldered printed circuit boards were designed to eliminate the possibility of cracked joints.

All piece parts selection was made from Hi-Rel parts list and/or the Electrical, Electronic and Electromechanical (EEE) parts list, with additional burn-in time specified for components where applicable. Additionally, a system of component derating was employed during circuit design in order to effect a worst-case analysis for that activity.

Component procurement was from approved vendor/supplier lists.

3.0 DESCRIPTION OF HARDWARE

3.1 Sensor Operation

The Electron-Proton Spectrometer (EPS) (Figure 3-1) has five sensors, each consisting of a shielded silicon detector, as shown in Figure 3-2, these provide four integral electron channels and five integral proton channels from which can be deduced four differential proton increments. Primary dose from high energy charged particles can be calculated utilizing the range energy relation for energy degradation. Hence, it can be seen that determination of the radiation dose inside a shield can be accomplished with knowledge of the shield thickness and the differential spectrum incident on the shield.

The sensitive element of the EPS sensor is the silicon detector which consists of a cube of lithium-drifted silicon crystal, as shown in Figure 3-3, operated as a reverse-biased diode. The ionization created along the path of an energetic charged particle passing through the sensitive volume of the detector provides a signal which is a measure of the energy deposited in the detector. Detection of electrons in the desired energy range will be accomplished by means of a low level discriminator, 200 - 300 keV, on each of the first four detector channels. Detection of protons in the desired energy range is accomplished by a higher discriminator setting, approximately 2 MeV on each of the five proton channels.

Separation of the protons and electrons is accomplished by the fact that only a negligible percentage of electrons can deposit enough energy to be counted in the proton channels. The electron channels must be corrected for the response to protons.

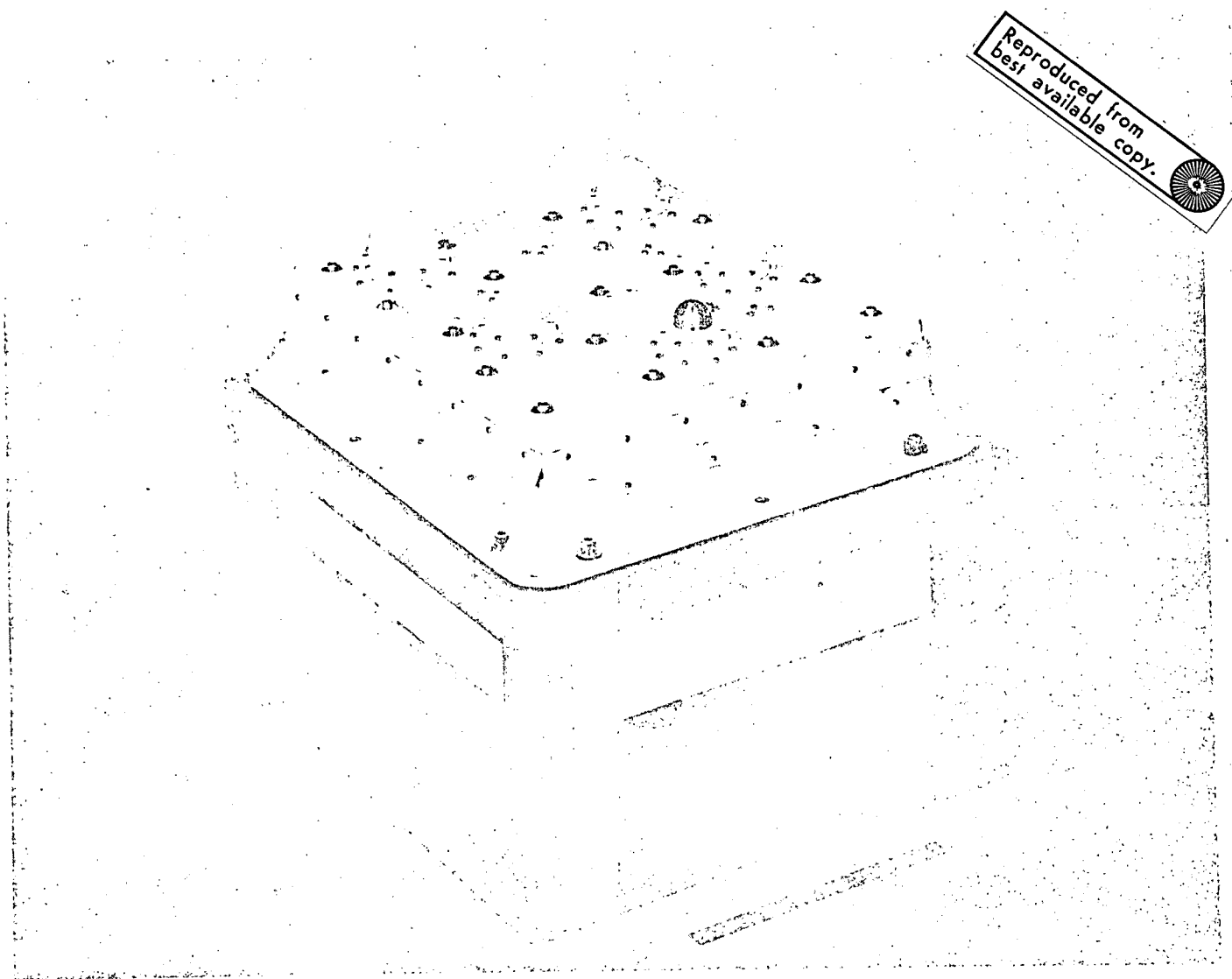


Figure 3-1. Photograph of EPS

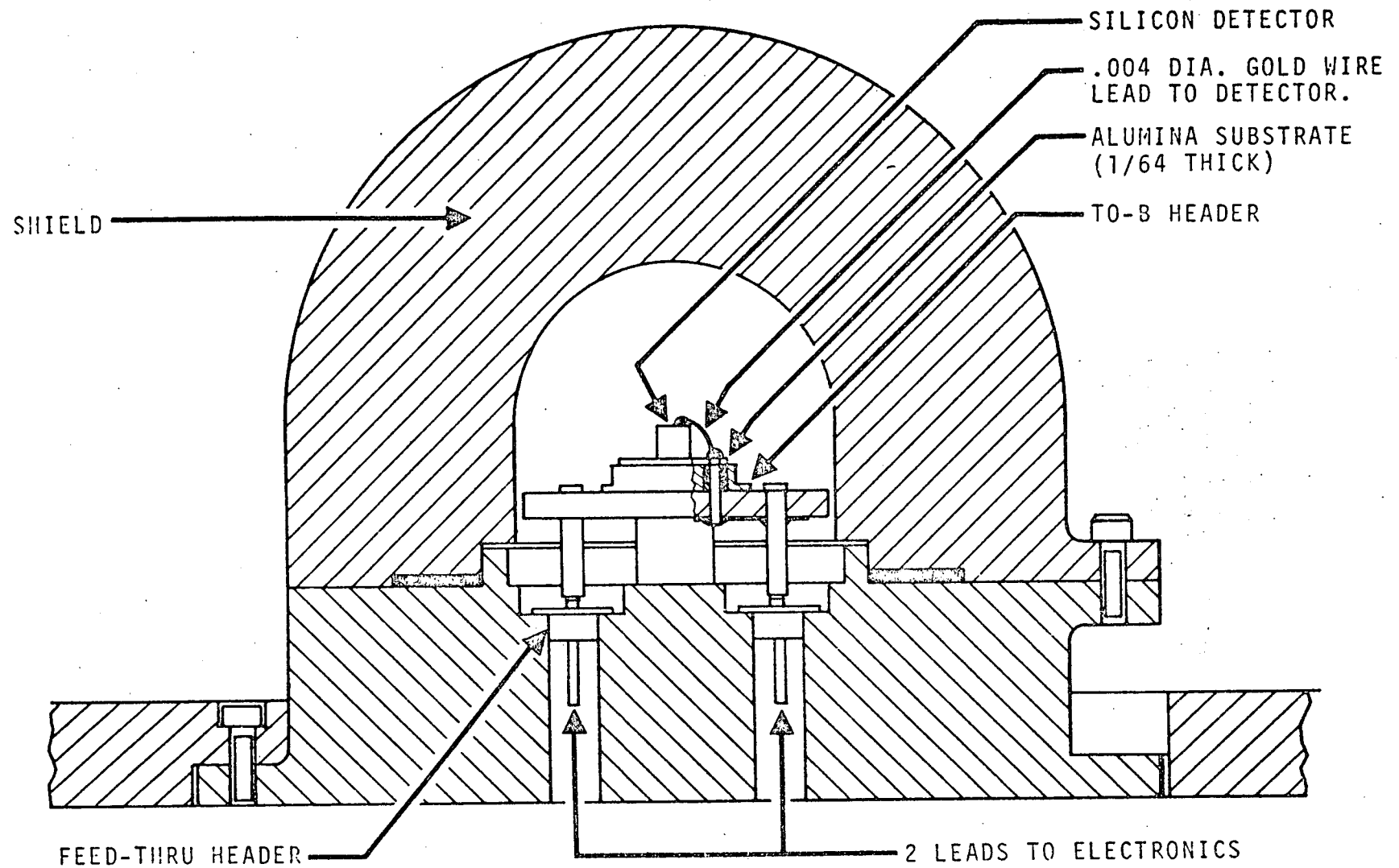


Figure 3-2. EPS Mounted Shielded Silicon Detector

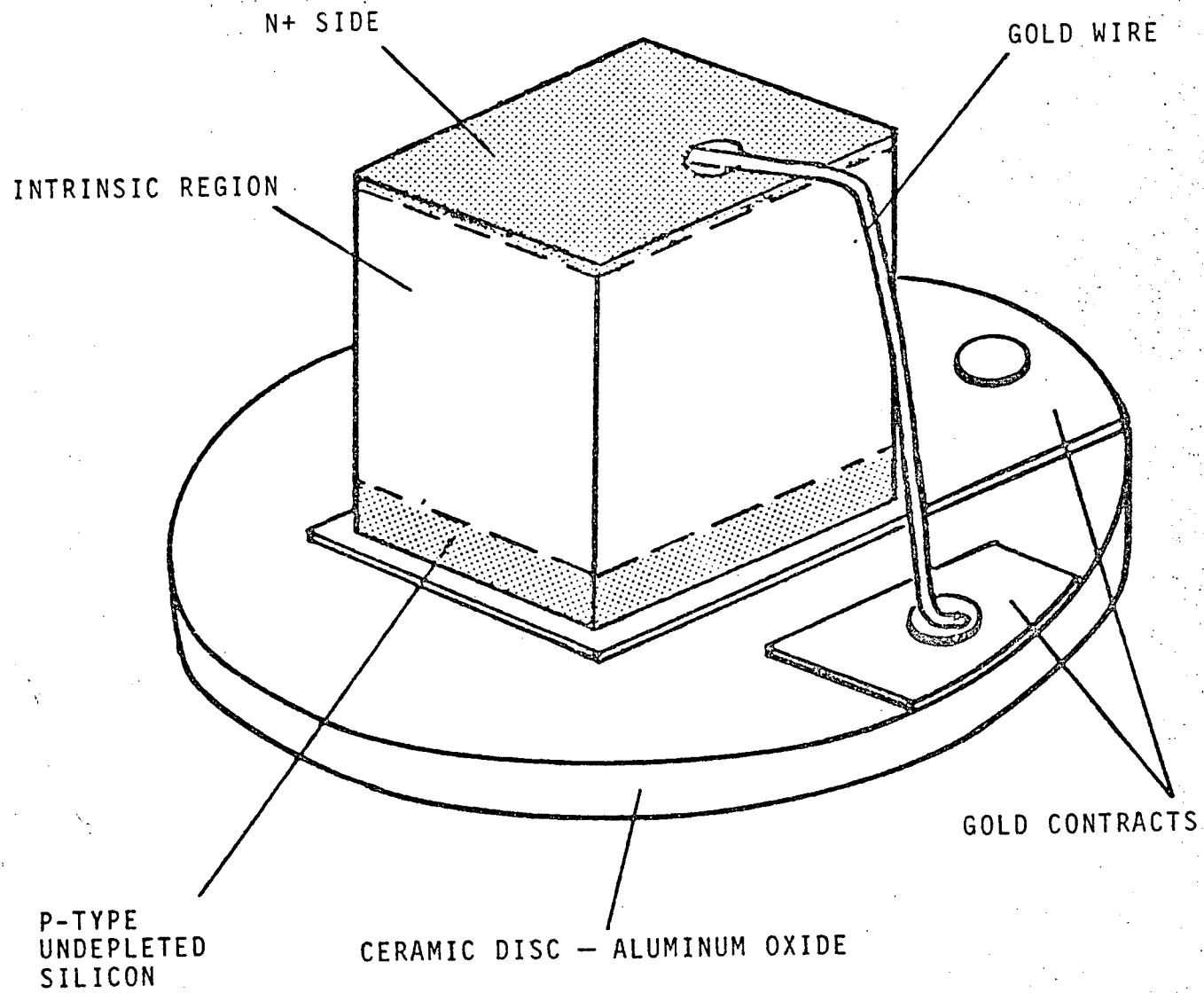


Figure 3-3. EPS Detector

3.1 Sensor Operation (Continued)

The parameters pertinent to the five detector channels are given in Table 3-1.

The EPS requirements of a 2π steradian acceptance solid angle and omnidirectionality within this angle require a detector of open geometry. The silicon detector is mounted exposed on an aluminum oxide disc which is mounted on a T05 transistor header. Electrical contact is made to the top of the silicon by a fine gold wire bonded with conducting epoxy. The silicon cube is epoxy bonded to the aluminum oxide disc.

As in any type of solid state detector, the EPS detectors exhibit a standing D.C. leakage current which in turn creates noise in the detector. The leakage current and hence the noise are directly proportional to temperature, although nonlinearly. Detector noise affects instrument operation in two ways: 1) By contributing to the degradation of energy resolution and, 2) By contributing false counts. Neither of these are expected, however, to be significant at the anticipated flight temperatures.

Construction of this type detector geometry requires leaving a region of uncompensated P-Type silicon to accomodate the continued drift of the lithium. The lithium drift rate is temperature and bias dependent. At the anticipated flight temperatures, however, the total drift during the mission is expected to be within tolerable limits.

TABLE 3-1
CHANNEL BOUNDARIES AND ENERGY LEVELS

<u>DETECTOR CHANNEL</u>	<u>DETECTOR SIZE (MM)</u>	<u>INTEGRAL PROTON BOUNDARIES (MEV)</u>	<u>SHIELD THICKNESS (CM)</u>	<u>DISC. LEVEL (MEV)</u>	<u>ELECTRON THRESHOLD ENERGY</u>
1	2	7.9	.037 AL	2	0.45
2	2	18.5	.180 AL	2	1.22
3	2	29.1	.406 AL	2	2.38
4	2	39.7	.710 AL	2	3.90
5	2	77.3	.890 BR	2	

NOTE: SHIELD MATERIAL

AL = ALUMINUM

BR = BRASS

3.1 Sensor Operation (Continued)

In the EPS detectors particles will enter the five exposed sides of the silicon cube, and in the case of the more energetic particles, will completely penetrate. A knowledge therefore of the active volume of the detector is necessary. Previous measurements have shown that the lateral dimensions can be manufactured rather accurately. The thickness in the direction of the lithium drift, however, will be ascertained for each detector by means of nuclear thickness measurements with a particle accelerator.

3.2 Electrical System Operation

The EPS electrical package consists of five systems, namely:

- Scientific Analog System
- Data Processor System
- Housekeeping System
- Power System
- Heater System

The functional interdependence of these systems is shown in Figure 3-4, Block Diagram Electron-Proton Spectrometer.

Scientific Analog System:

The purpose of the Scientific Analog System (see block diagram, Figure 3-5) is to detect the random occurrence of current impulses emanating from the EPS detectors, determine if the total impulse charge exceeds a predetermined value, and if so submit an outside signal for recording by the Data Processor. There are five scientific channels which are:

- Independent

- Adjustable in counting level to allow use with
detectors having variable dimensions

- Capable of single valued counting-rate performance
to 10^6 counts per second

- Immune to detector generated noise

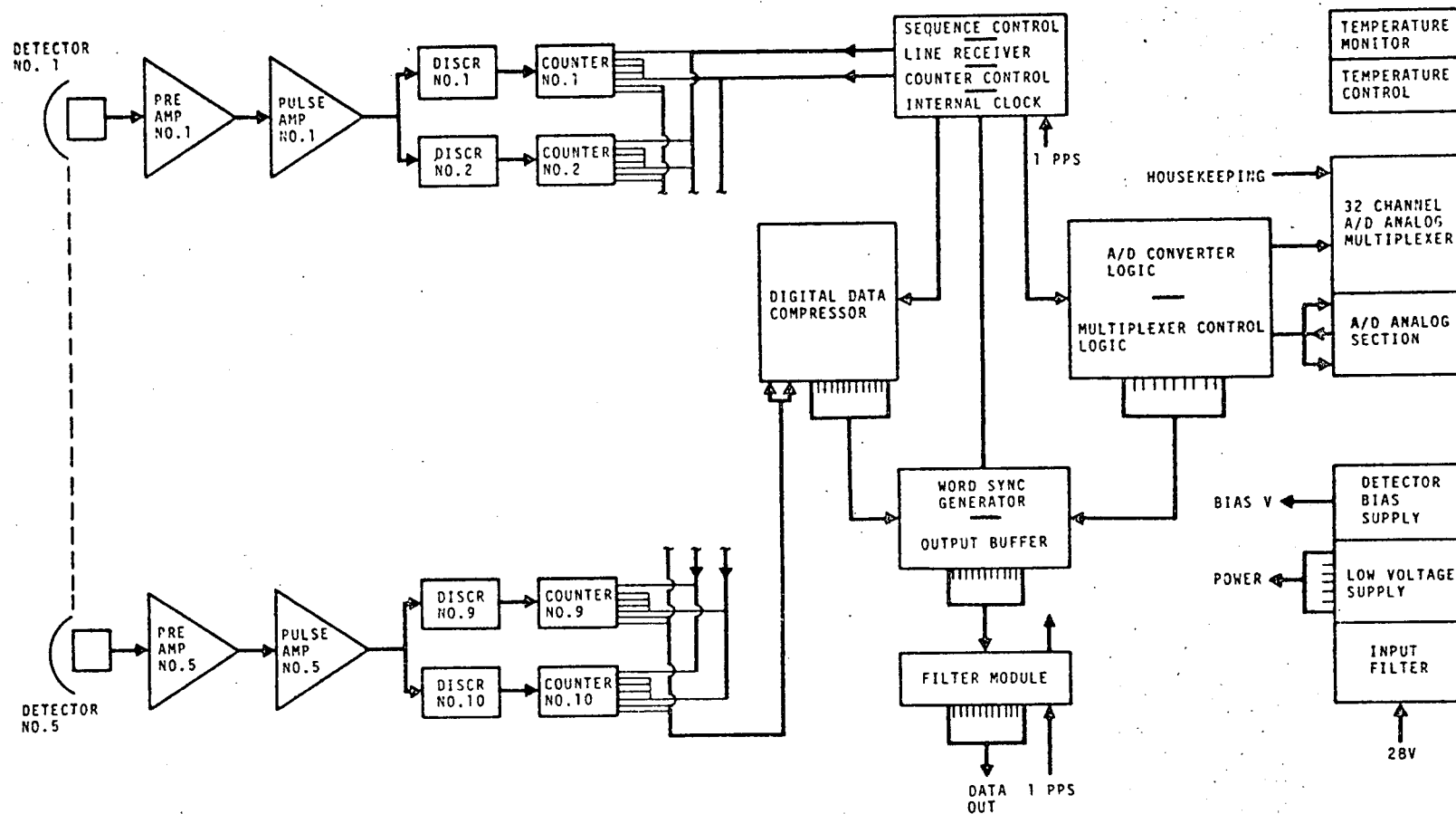


Figure 3-4. System Block Diagram

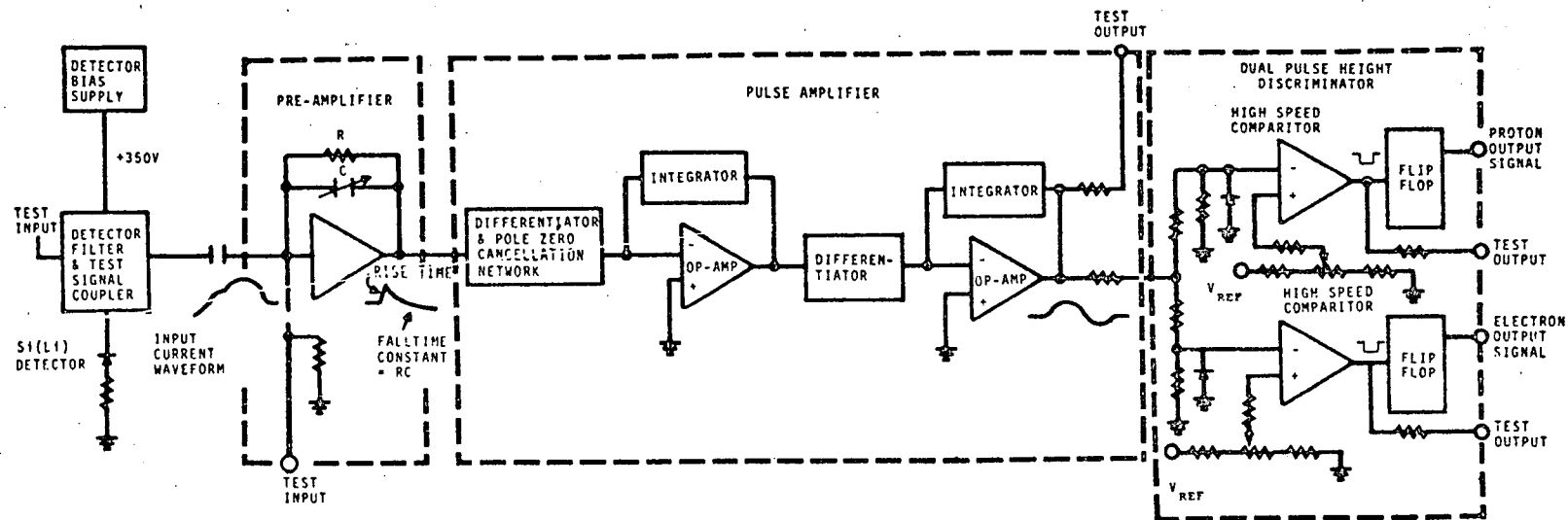


Figure 3-5. Analog System Schematic

3.2 Electrical System Operation (Continued)

Each scientific channel is made up of a preamplifier, a pulse amplifier, and a dual pulse height discriminator.

The preamplifier converts the detector's current impulse to a slowly decaying step function whose amplitude is proportional to the total charge input. The pulse amplifier filters this step input producing a bipolar waveform at its output. The dual pulse height discriminator compares the bipolar waveform to two reference levels. If the input waveform exceeds either of these two reference levels, a corresponding output pulse is directed to a prescaler. The prescaler generates an output signal for every other excitation of the discriminator.

Data Processor System:

The function of the Data Processor is to digitally integrate the prescaler outputs individually and present the information to the spacecraft telemetry system in an acceptable form under control of the spacecraft. This integration provides 12 seconds of counting for every 13 seconds of real time. In addition, the Data Processor accepts analog housekeeping signals, digitizes them sequentially and properly mixes this with the scientific information. The data processor utilizes high reliability, low power TTL logic in its digital section and high reliability low power amplifiers in its analog to digital converter section.

3.2 Electrical System Operation (Continued)

Housekeeping System:

The Housekeeping System provides signals to the Data Processor analog to digital converter that yield information concerning the operational status of all important EPS parameters. Those functions monitored include:

- detector leakage currents
- detector resolutions
- electronic package temperature
- detector plate temperature
- power supply levels
- heater status

Power System:

The EPS Power System was designed to receive the +28 V available from the spacecraft and provide the power output voltages to both the EPS detectors and the electronic subsystems. Major subsystems are:

The Low Voltage Power Supply: Receives filtered +28 V which is regulated down to +20 Vdc by utilizing a switching regulator. The regulator output is then utilized by the dc/dc converter. There are three separate output windings on the dc/dc converter transformer. These windings produce six different output voltages. One of these outputs (the +8 V) is also regulated down to +3.0 V to provide a stable reference voltage for the pulse-height discriminator sub-assemblies.

3.2 Electrical System Operation (Continued)

Detector Bias Supply: Receives +28 V which is regulated down to +21 Vdc in order that the bias applied to the EPS detectors will not be affected by fluctuations in the spacecraft power lines. This regulated +21 Vdc is then fed to the dc/dc converter which generates a 350 volt square wave. This is rectified, filtered and applied to the detectors cathode thru the bias filter subassembly.

Heater System:

The Heater System functions in a temperature control capacity. An internal temperature sensor is continually monitored by control circuitry. If the package temperature drops below 0°C, six watts of power is dissipated in the inner housing structure by heaters. When the temperature rises above 10°C, the six watts of power is removed. The temperature sensing circuit consists of a thermistor and schmitt trigger. The output of the schmitt trigger is amplified and utilized to apply power, as necessary, to four individual skin heaters bonded to the electronics assembly housing. The schmitt output is also buffered and routed to the EPS Data Processor to provide the status of the EPS heaters (i.e., whether on or off).

3.3 Data System Operation

The data system is required to digitize all data and present it in the correct format and time to the telemetry system. The data must be identified so that after shutdown periods, specific data channels may be quickly recognized.

The data processor section is composed of seventeen modules mounted on a common motherboard. A pictorial view is shown in Figure 3-6. The module breakdown is as follows:

Counter-Register	10 ea.
Sequence Control, Line Receiver, Counter Control	1 ea.
Data Compressor and Internal Clock	1 ea.
Output Buffer and Word Sync Generator	1 ea.
Analog - Digital Converter	1 ea.
A/D Control	1 ea.
Multiplexer	1 ea.
Monitor Module	1 ea.

There are ten channels of detector information, plus twenty-one sources of house-keeping information. This data is processed and formatted to be read out on 13 data lines which are sampled 1 time per second. The EPS Word Format and Main Frame Format are shown in Figure 3-7 and 3-8 respectively. All timing sequences are referred to a single clock pulse of one Hertz, which is fed to the instrument from the CSM.

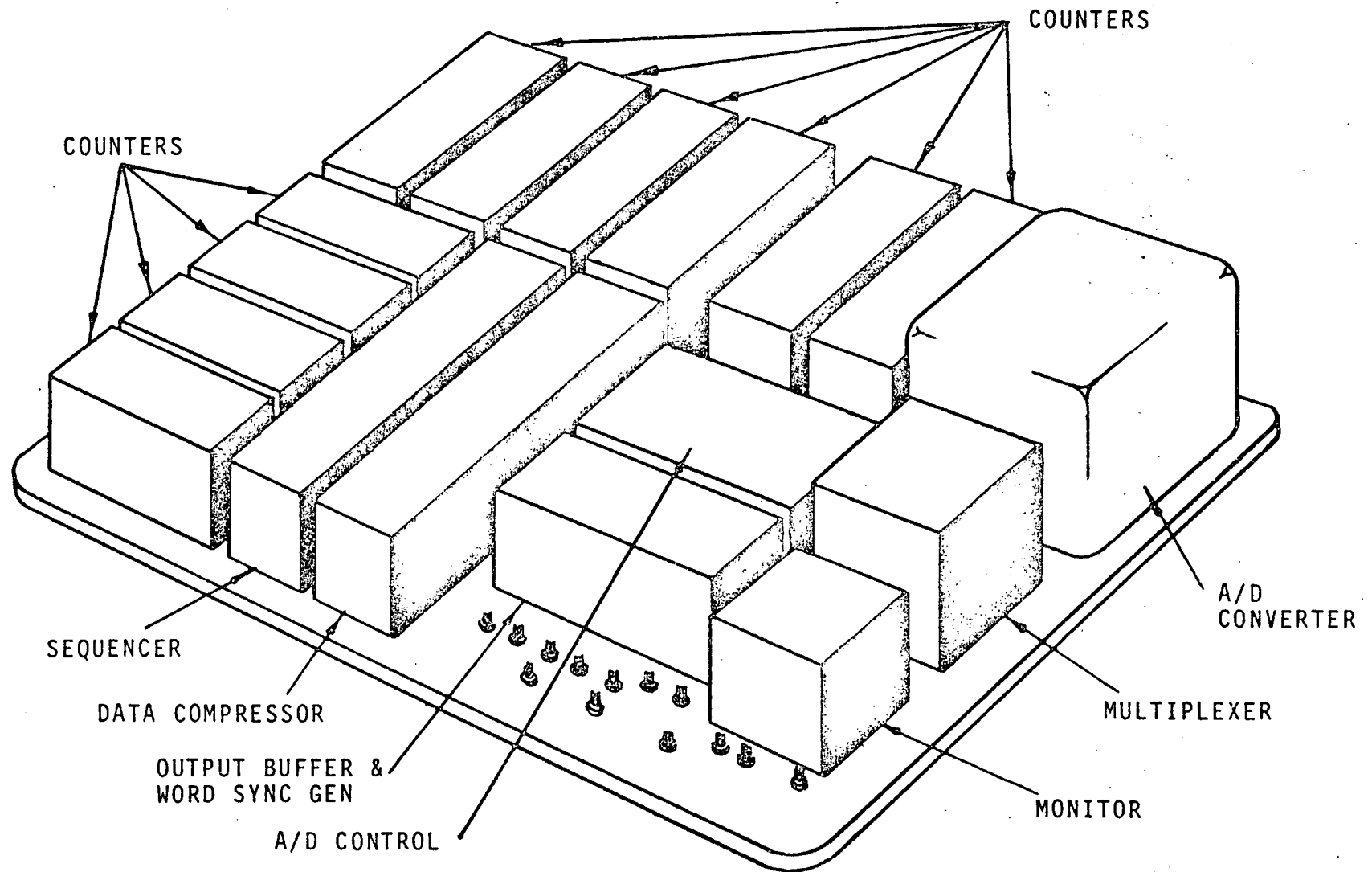
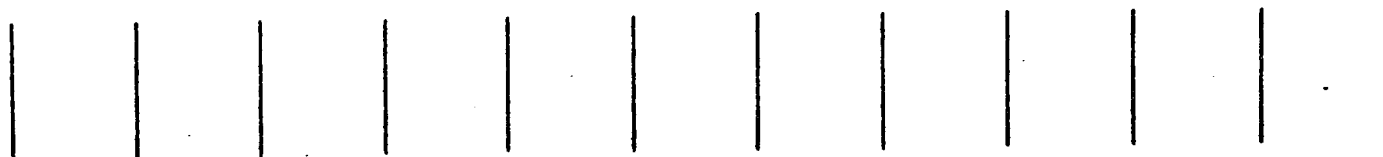


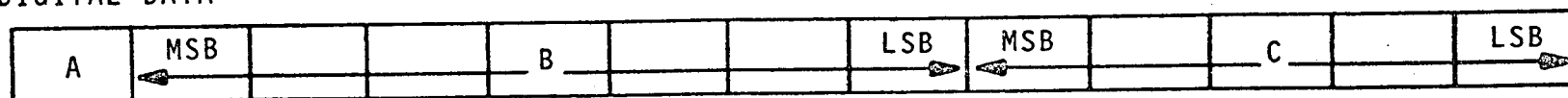
Figure 3-6. Data Processor Mother Board

PRIME FRAME SYNC

1	2	3	4	5	6	7	8	9	10	11	12	13
0	1	1	1	0	0	0	1	0	0	1	0	1



DIGITAL DATA



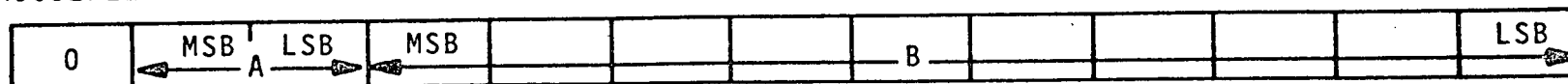
A - WORD SYNC (BINARY 0 FOR ALL WORDS EXCEPT ELECTRON 1)

B - DATA

C - PLACE



HOUSEKEEPING DATA



A - HOUSEKEEPING SYNC

B - DATA

Figure 3-7. EPS Word Format

3.3 Data System Operation (Continued)

The spacecraft information interface consists of thirteen bilevel data lines and one synchronizing command line. The thirteen bilevel lines are sampled, in parallel, at a rate of 1 Hz with each sample occurring a minimum of 20 milliseconds after the positive going transition of the 1 Hz synchronizing command. Scientific data accumulation specifications are:

1. Counting Interval - 12 seconds
2. Recording Interval - 13 seconds
3. Fractional Counter Livetime - 92.3%
4. Counter Capacity - $2^{24}-1 = 16,777,215$ events/channel
5. Counting Rate Maximum - 2.80×10^6 cps/channel for no overflow.
6. Readout Format - Floating point binary compression, seven bit word plus five bit place word.
7. Digital Accuracy - $\pm 0.5\%$ of value

The EPS Housekeeping data accumulation specifications are:

1. Sample Rate - .154/sec
2. Sample Rate Per Channel - .0048/sec
3. Conversion Gain - 10 bits
4. Number of Channels - 32
5. Address, Range, Resolution, Accuracy - See Table 3-2

TABLE 3-2. TYPICAL EPS DATA PROCESSOR HOUSEKEEPING SEQUENCE
PARAMETER RANGE, ACCURACY, AND RESOLUTION CHART

PRIME FRAME NO.	HOUSE- KEEPING ID ID BIT BIT		MEASUREMENT	RANGE	ACCURACY	RESOLUTION
	2	3				
1A	0	0	Package Temperature	-50°C to +50°C	±1.0°C	0.110°C
2A	0	0	Detector 1 Noise	0 to 100 keV	±10 keV	1.0 keV
3A	0	0	Detector 1 Leakage	0.05 µA to 20 µA	±0.05 µA	0.02 µA
4A	0	0	Detector Plate Temp	-50°C to +50°C	±1.5°C	0.110°C
5A	0	1	Detector 2 Noise	0 to 100 keV	±10 keV	1.0 keV
6A	0	1	Detector Leakage	0.05 µA to 20 µA	±0.05 µA	0.02 µA
7A	0	1	+5 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
8A	0	1	Detector 3 Noise	0 to 100 keV	±10 keV	1.0 keV
9A	1	0	Detector 3 Leakage	0.05 µA to 20 µA	±0.05 µA	0.02 µA
10A	1	0	+8 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
11A	1	0	-8 Volt Monitor	0 volts to -10 volts	±50 mv	10 mv
12A	1	0	+25 Volt Monitor	0 volts to +55 volts	±27 mv	54 mv
13A	1	1	350 Volt Monitor	0 volts to 505 volts	±250 mv	500 mv
14A	1	1	-15 Volt Monitor	0 volts to -20 volts	±100 mv	20 mv
15A	1	1	-5 Volt Monitor	0 volts to -10 volts	±50 mv	10 mv
16A	1	1	Discrim. Ref. Mon.	0 V to 6.002 V	±3 mv	6 mv
1B	0	0	Package Temperature	-50°C to +50°C	±1.5°C	0.110°C
2B	0	1	Detector 4 Noise	0 to 100 keV	±10 keV	1.0 keV
3B	1	0	Detector 4 Leakage	0.05 µA to 20 µA	±0.05 µA	0.02 µA
4B	1	1	Detector Plate Temp	-50°C to +50°C	±1.5°C	0.110°C
5B	0	0	Detector 5 Noise	0 to 100 keV	±10 keV	1.0 keV
6B	0	1	Detector 5 Leakage	0.05 µA to 20 µA	±0.05 µA	0.02 µA
7B	1	0	+5 Volt Monitor	0 volts to +10 volts	5 mv	10 mv
8B	1	1	Heater Monitor	On/Off	--	--
9B	0	0	Heater Monitor	On/Off	--	--
10B	0	1	+8 Volt Monitor	0 volts to +10 volts	±5 mv	10 mv
11B	1	0	-8 Volt Monitor	0 volts to -10 volts	±50 mv	10 mv
12B	1	1	+25 Volt Monitor	0 volts to +55 volts	±27 mv	54 mv
13B	0	0	350 Volt Monitor	0 volts to 505 volts	±250 mv	500 mv
14B	0	1	-15 Volt Monitor	0 volts to -20 volts	±100 mv	20 mv
15B	1	0	-5 Volt Monitor	0 volts to -10 volts	±50 mv	10 mv
16B	1	1	Discrim. Ref. Mon.	0 V to 6.0020 V	±3 mv	6 mv

3.4 Mechanical Design

As can be seen from Figure 3-9 Diagram of the EPS, the instrument package consists essentially of an outer housing and an electronics package.

The outer housing is combined with the mounting flange of the instrument, and is hard-mounted to the spacecraft support structure. As described under thermal design (section 3.5), the mounting flange incorporates glass-fiber bushings at the hold-down bolt holes to isolate the instrument thermally from the spacecraft structure. Additionally, a silicon rubber 'O-ring' cord seal is provided on the underside of the flange to seal the 1/16" gap between the flange and spacecraft structure, to maintain N.A.R.'s differential pressure requirement for a controlled leak rate of the CSM. The baseplate is an integral part of the outer housing and carries the electrical connectors to interface with the spacecraft wiring. Two grounding straps are attached to the outer housing at two hold-down bolt locations and make contact with the spacecraft structure when the instrument is in position.

The electronics unit is supported within the outer housing by means of 8 vibration isolators. These isolators reduce the shock and vibration inputs to acceptable levels for survival of the various electronics within the unit, and also provide additional thermal and electrical isolation from the main structure.

The top plate and electronics housing comprise the electronics unit. Radiation detectors are mounted to the top plate and wired to their respective electronics,

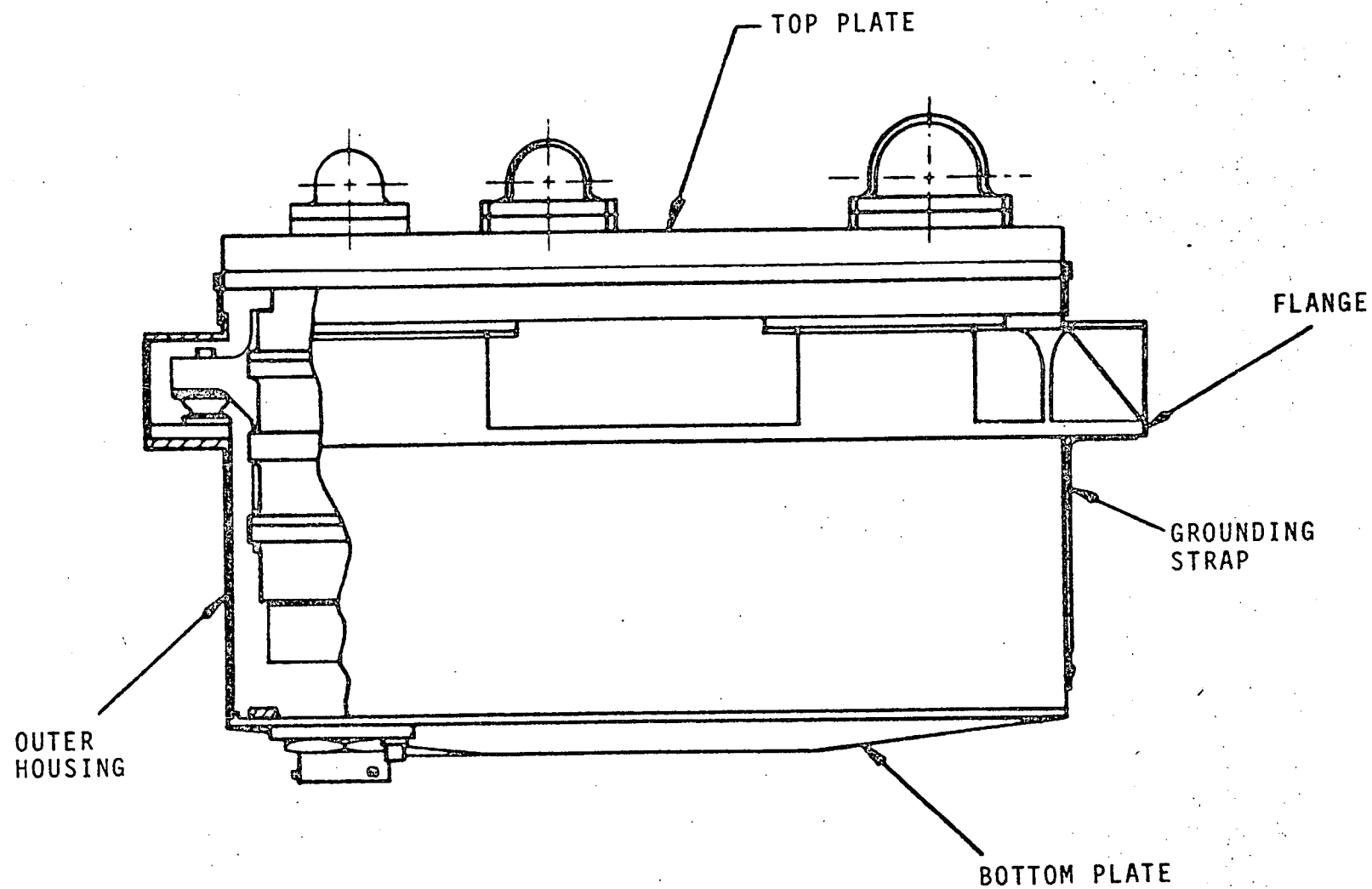


Figure 3-9. Diagram of EPS

3.4 Mechanical Design (Continued)

and the top plate is mounted on the electronics package as described under thermal design (section 3.5). A reflective shield covers the gap between the top plate and outer housing required to accommodate the movement of the vibration isolators under shock, vibration and acceleration conditions. Figure 3-10, cross-section view of the EPS shows in more detail how the structure and electronics are arranged.

The Modular Electronic Packaging Design (Figure 3-11) made possible the separate development of the various portions as the circuit design for the individual functions became established.

Each slice incorporates its own housing, structure integrity, circuit board mounting thermal transfer paths, and its connectors.

Each printed circuit board mounts in a completely enclosed cavity in the slice. The cards' circuit ground plane around its perimeter is completely in contact with the slice mounting flange, thus providing excellent signal return and thermal transfer paths. This enables circuitry such as the detector bias supply, inherently noisy, to be placed in the pre-amplifier slice, avoiding any interference with the pre-amplifier's sensitive circuitry. Each of the five data channels are electrostatically shielded from each other as well as from the other circuitry. The exceedingly large common ground (ground plane) areas reduces noise pickup and capacitance and also serves as a thermal transfer path thus reducing component hotspots and at the same time providing structural integrity at minimum weight.

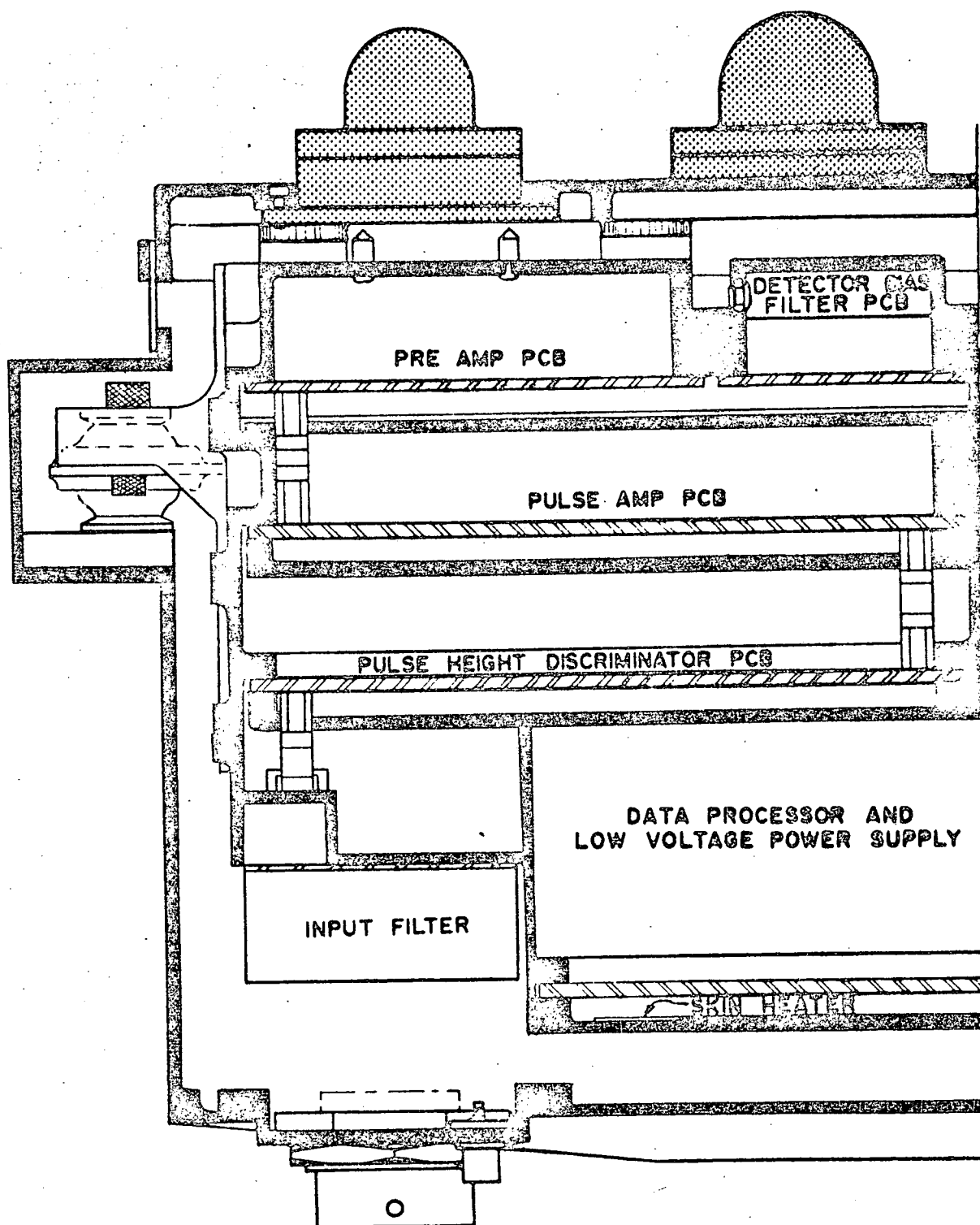


Figure 3-10. Cross Section View of EPS

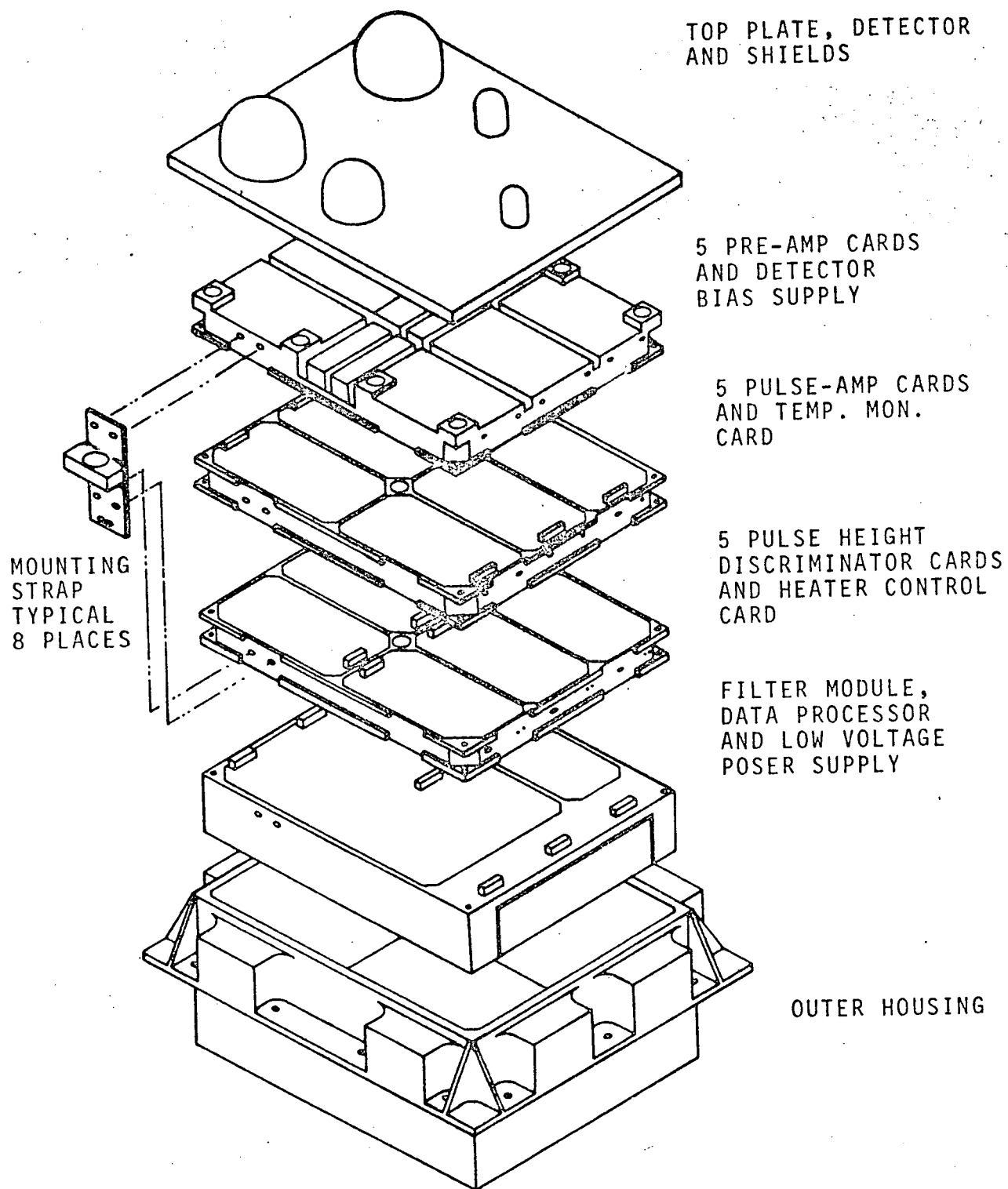


Figure 3-11. Packaging Concept of Electron-Proton Spectrometer

3.4 Mechanical Design (Continued)

Each slice housing serves as a basic structure for the assembly, a chassis for mounting circuit boards and parts, a transfer medium for signal return, thermal heat sink, and shielding for electrostatic interference protection.

Among the advantages offered by this packaging design are:

- Provides accessibility to printed circuit boards and their components.
- Permits removal and replacement on individual slices without rewiring.
- Enabled the utilization of one printed circuit board layout for the detector bias filter, pre-amp, post amp, pulse height discriminator.

3.5 Thermal Design

The thermal design of the Electron-Proton Spectrometer is based on providing thermal control of the instrument by passive techniques for normal continuous operation. An integral heater for maintaining the instrument at survival temperature in the event of the need to reduce power to the instrument is provided. This heater may be used to provide additional heating during cold orbits if required.

The thermal design provides adequate thermal control for normal continuous operation of the EPS when not directly oriented toward the sun.

As can be seen from the thermal control diagram (Figure 3-12), the instrument is isolated from the spacecraft structure by means of glass-fibre bushings at each of the hold-down bolt locations. This minimizes the effect that variations in the spacecraft skin temperature has upon the instrument temperature. The vibration isolators, by virtue of their material (silicone rubber) and construction, provide additional isolation of the electronics package from the outer structure of the instrument.

The top plate and electronics package comprise a unit that is isolated thermally from the rest of the structure. The thermal interface between the two assemblies has been designed to provide a temperature gradient of 30 - 50°F since the electronics assembly is required to run warmer than the detectors. Cat-a-lac

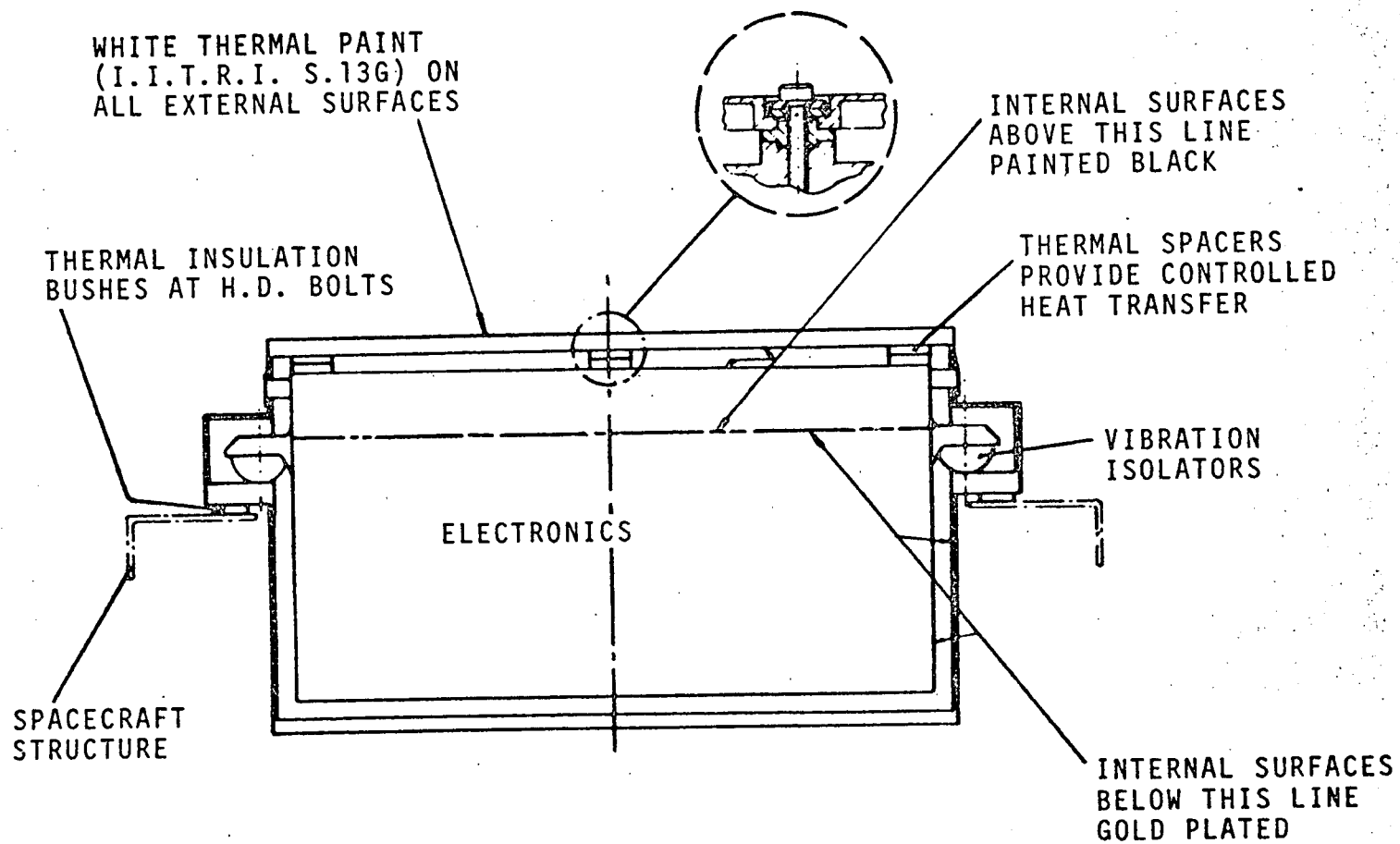


Figure 3-12. Thermal Control Diagram

3.5 Thermal Design (Continued)

black enamel is applied to the two opposing faces in order that about 50% of the internal power be radiated to the top plate. Radiant coupling increases with temperature, thus tending to prevent exceedingly high or low temperatures in the electronics assembly. The remainder of the internal power is conducted to the top plate through four electrical grounding straps and twenty-one glass-fiber spacers, whose size and material have been selected to provide a controlled thermal conductance.

The heaters are mounted in the bottom slice of the electronics package, and their operation is controlled by an internal sensor monitoring the temperature of the electronics. The heaters are programmed to turn on when the electronics temperature reaches +32°F and turn off when the temperature has risen to +50°F.

During the design and development of the EPS printed circuit (pc) board and welded module subassemblies, due consideration was given to the elimination of thermal "hot spots" within these subsystems to comply with the derating requirements of the EPS. During the design and fabrication of the EPS Thermal Test Unit, an effort was also made to simulate, as close as possible, the actual heat profile of these subsystems. This was done to determine if there were components within certain subsystems, which might reach temperatures approaching the derating temperature limits of the electronic components.

4.0 TEST VERIFICATION PROGRAM

DEFINITION OF HARDWARE NOMENCLATURE

Development Test Unit: Two separate units one structural and one thermal mockup fully instrumentated with simulated electronics.

Engineering Test Unit: Prototype made to simulate as close as possible the final design structurally and electrically. Electrical systems used off the shelf type components that functioned identical to flight hardware

Qualification Test Unit: Fabricated identically the same as flight hardware.

4.1 Developmental Test Unit. Summary

<u>Test</u>	<u>Result</u>
Thermal-Vacuum	<p>Generally, the test confirmed the analytical approach and selection of coatings for thermal control. The use of a controlled heat leak to control the electronics temperature was shown to be satisfactory, though the results underlined the fact that the insulation between the electronics package and outer housing was a critical item in the assembly.</p> <p>The test also provided the data required for selection of potting compounds and confirmed the selection of derating temperatures used in the electronics design.</p>
Vibration	<p>The test responses are considered to be satisfactory for survival of the detectors and electronics. Deflections, appear to be within predicted values, hence, it is considered that the revised design provides a solution to the vibration problem that will allow the electronics package to be qualified to the vibration levels imposed on the EPS.</p> <p>The results of the resonant search indicate that the natural frequency range of the vibration isolators is so dominant, and their attenuation so effective, that no significant resonance is seen on the electronics package and its inherent parts.</p>

4.1 Development Test Unit. Summary (Continued)

Shock

Visual examination of the test item showed no failures, loose components, etc. and comparison of the results of monitoring the response levels indicated no problem areas. Hence, the test was considered to have satisfactorily fulfilled its purpose.

Breadboard

Design Information

The MSCM Component Derating Standard was used as a minimum in establishing circuit operating levels, component power levels/dissipation.

Each circuit/subsystem were thoroughly thermally cycled over the anticipated survival temperature range to ensure proper operation.

4.1.1 Development Test Program

4.1.1.1 Thermal-Vacuum Test

TEST CASE	INSTRUMENT MODE	POWER	SIMULATED β ANGLE	HOT OR COLD	ABSORBED HEAT FLUX (BTU/HR-FT ²)		BOUNDARY TEMP (°F)	
					TOP	SIDES	SKIN	CAVITY
1	OPERATING	ELECTRONICS ONLY	0°	Hot	33.8	16.0	-23	75
2	OPERATING	ELECTRONICS & HEATERS	±73-1/2°	Cold	18.2	13.9	-75	0
3	STANDBY	HEATER ONLY	±73-1/2°	Cold	18.2	13.9	-75	0
4	SURVIVAL	NONE	±73-1/2°	Cold	18.2	13.9	-75	0
5	SURVIVAL	NONE	0°	Hot	26.8	12.9	-23	75
6	PRE-DOCKING	NONE	±73-1/2°	Hot	128	13.9	250	75
7	PRE-DOCKING	ELECTRONICS ONLY	±73-1/2°	Hot	128	13.9	250	75

NOTE: Vacuum 1×10^{-6} Torr or Better

4.1.1.2 Vibration

Random

R-Axis

20 to 125 Hz	+12 dB/oct
125 to 500 Hz	$2.0 \text{ g}^2/\text{Hz}$
500 to 670 Hz	-9 dB/oct
670 to 1100 Hz	$0.8 \text{ g}^2/\text{Hz}$
1100 to 2000 Hz	-9 dB/oct

Nominal 41 g (rms)

X-Axis

20 to 75 Hz	+6 dB/oct
75 to 175 Hz	$0.085 \text{ g}^2/\text{Hz}$
175 to 300 Hz	+6 dB/oct
300 to 1000 Hz	$0.25 \text{ g}^2/\text{Hz}$
1000 to 2000 Hz	-6 dB/oct

Nominal 30 g (rms)

T-Axis

20 to 100 Hz	+6 dB/oct
100 to 440 Hz	$0.04 \text{ g}^2/\text{Hz}$
440 to 600 Hz	+18 dB/oct
600 to 900 Hz	$0.3 \text{ g}^2/\text{Hz}$
900 to 2000 Hz	-12 dB/oct

Nominal 23 g (rms)

For each of the above axes, duration is 140 seconds plus
10 seconds at 4 dB above the nominal.

4.1.1.2 Vibration (Continued)

Sinusoidal A 3.6 g sinusoidal resonant search, from 5 - 2000 Hz at a sweep rate of 1 octave/minute conducted on the original

4.1.1.3 Shock

Test per MIL STD 810B; Method 516.1 Procedure 1 at 20 g's 3 shocks in each direction on three mutually perpendicular axes (total 18 shocks).

4.1.1.4 Breadboard

Informal component and circuit testing to obtain final design information.

4.2 Engineering Test Unit Summary

<u>Test</u>	<u>Result</u>
Thermal-Vacuum	Test confirmed analytical studies and verified the selection of thermal control material.
Vibration	Test confirmed selection of vibration isolators.
Shock	Test did not result in any electrical or mechanical failures.
EMC	Test Results were satisfactory.
End-to-End	Test confirmed proper functioning of EPS when exposed to electrons and protons. Provides a complete functional performance check of the instrument from the excitation of the sensor to and including the data processor and equipment test set.

4.2.1 Engineering Test Program

4.2.1.1 Thermal-Vacuum Test

TEST CASE	INSTRUMENT MODE	POWER	SIMULATED β ANGLE	HOT OR COLD	ABSORBED HEAT FLUX (BTU/HR-FT ²)		BOUNDARY TEMP (°F)	
					TOP	SIDES	SKIN	CAVITY
1	OPERATING	ELECTRONICS & HEATERS	0°	Hot	33.8	16.0	-23	75
2	OPERATING	ELECTRONICS & HEATERS	$\pm 73-1/2^\circ$	Cold	18.2	13.9	-75	0
3	STANDBY	HEATER ONLY	$\pm 73-1/2^\circ$	Cold	18.2	13.9	-75	0
4	SURVIVAL	NONE	$\pm 73-1/2^\circ$	Cold	18.2	13.9	-75	0
5	SURVIVAL	NONE	0°	Hot	26.8	12.9	-23	75
6	PRE-DOCKING	NONE	$\pm 73-1/2^\circ$	Hot	128	13.9	250	75
7	PRE-DOCKING	ELECTRONICS ONLY	$\pm 73-1/2^\circ$	Hot	128	13.9	250	75

NOTE: Vacuum 1×10^{-6} Torr or Better

4.2.1.2 Vibration

Random

R-Axis

20 to 125 Hz	+12 dB/oct
125 to 500 Hz	$2.0 \text{ g}^2/\text{Hz}$
500 to 670 Hz	-9 dB/oct
670 to 1100 Hz	$0.8 \text{ g}^2/\text{Hz}$
1100 to 2000 Hz	-9 dB/oct

Nominal 41 g (rms)

X-Axis

20 to 75 Hz	+6 dB/oct
75 to 175 Hz	$0.085 \text{ g}^2/\text{Hz}$
175 to 300 Hz	+6 dB/oct
300 to 1000 Hz	$0.25 \text{ g}^2/\text{Hz}$
100 to 2000 Hz	-6 dB/oct

Nominal 30 g (rms)

T-Axis

20 to 100 Hz	+6 dB/oct
100 to 440 Hz	$0.04 \text{ g}^2/\text{Hz}$
440 to 600 Hz	+18 dB/oct
600 to 900 Hz	$0.3 \text{ g}^2/\text{Hz}$
900 to 2000 Hz	-12 dB/oct

Nominal 23 g (rms)

For each of the above axes, duration is 140 seconds plus 10 seconds at 4 dB above the nominal.

4.2.1.2 Vibration (Continued)

Sinusoidal:

Each Axis - Sweep from 5 to 35 to 5 Hz at .25 g peak.

Sweep Rate - 3 octaves/min.

4.2.1.3 Shock

Test per MIL STD 810B, Method 516.1 Procedure 1 at 20 g's 3 shocks in each direction on three mutually perpendicular axes (total 18 shocks).

4.2.1.4 EMC

Tests were performed in accordance with NR specifications MH04-02057-234 and IRN 9395.

Test Method	Freq. Range	Spec Limits
<u>Conducted Interference</u>		
Oscilloscope	0 Hz - 15 KHz	0.8 V P-P
Current Probe	0 Hz - 25 MHz	--
<u>Radiated Interference</u>		
Rod Antenna	15 KHz - 25 MHz	--
Dipole Antenna	25 MHz - 1000 MHz	--
Directive Antenna	1000 MHz - 10,000 MHz	--

4.2.1.4 EMC (Continued)

Conducted Susceptibility

RF	50 KHz - 400 MHz	100,000 μ V
Audio	20 Hz - 50 KHz	--
50 V Transient	10 PPS - 2 Min	+50 V Peak
0.5 V Transient	10 PPS - 2 Min.	\pm 0.5 V Peak

Radiated Susceptibility

Rod Antenna	0.14 - 20 MHz	1.0 V/M
Biconical Antenna	20 - 200 MHz	1.0 V/M
Conical Loc Spiral Antenna	200 - 13,000 MHz	1.0 V/M except as follows:
		250 - 300 MHz 2V/M
		2270 - 2290 MHz 15V/M
		9800 - 9850 MHz 7V/M

Induced Field Susceptibility

Equipment	400 Hz	10 Amp. thru 5 Ft. of wire
Cabling	400 Hz	40 Amp. Feet

4.2.1.5 End-to-End Testing

To exercise all channels of the instrument the following tests were conducted:

Protons: Tests were performed in seven steps over the energy range from
23 to 130 MeV.

Electrons: Tests were performed in three steps over the energy range from
2.7 to 4 MeV.

4.3 Qualification Test Unit Summary

<u>Test</u>	<u>Results</u>
Thermal-Vacuum	Functions within operation limitations
Vibration, Sine	Functions after exposure
Vibration, Random	No damage attributable to vibration
Pyrotechnic Shock	No physical damage noted
Bench Handling Shock	No physical damage noted
Acoustic	No damage attributable to acoustic
Humidity	Functions after exposure
EMC	No out of limit conditions noted
Minimum Useful Life (Analysis)	All parts/components exceed requirements
Storage (Analysis)	All materials used meet storage requirements.

4.3.1 Qualification Test Program

4.3.1.1 Thermal-Vacuum

Test Case	Instrument Mode	Power	Simulated β Angle	Hot or Cold	Absorbed Heat Flux (BTU/Hr-Ft ²)		Boundary Temp. (°F)	
					Top	Sides	Skin	Cavity
1	Operating	Electronics and Heaters	$\pm 73 \frac{1}{2}^\circ$	Cold	18.2	13.9	-75	0
2	Standby	Heater Only	$\pm 73 \frac{1}{2}^\circ$	Cold	18.2	13.9	-75	0
3	Operating	Electronics Only	0	Hot	33.8	16.0	-23	75
4	Pre-Docking	None	$\pm 73 \frac{1}{2}^\circ$	Hot	128	13.9	250	75

NOTE: Vacuum 1×10^{-6} Torr or Better.

4.3.1.2 Vibration, Sinusoidal

Sweep from 5 to 35 to 5 Hz at .25 g peak.

Sweep rate: 3 octaves/min.

(Applicable to all 3 axes of the instrument)

4.3.1.3 Vibration, Random

R-Axis

Max g and liftoff simulation

20 to 175 Hz	+ 9 dB/octave	
175 to 350 Hz	6.0 g ² /Hz	80 seconds
350 to 2000 Hz	- 3 dB/octave	(70.5 g rms)

Transonic/Mach 1 simulation

20 to 175 Hz	+ 9 dB/octave	
175 to 350 Hz	10.0 g ² /Hz	10 Seconds
350 to 2000 Hz	- 3 dB/octave	(91 g rms)

X-Axis

20 - 75 Hz	+ 6 dB/oct	
75 - 175 Hz	.085 g ² /Hz	80 seconds at nominal
175 - 300 Hz	+ 6 dB/oct	18.2 g rms plus 10 seconds
300 - 1000 Hz	.25 g ² /Hz	at 4 dB above nominal
1000 - 2000 Hz	- 6 dB/oct	28.8 g rms.

T-Axis

20 - 100 Hz	+ 6 dB/oct	
100 - 440 Hz	.04 g ² /Hz	80 seconds at nominal
440 - 600 Hz	+ 19 dB/oct	14.4 g rms plus 10 seconds
600 - 900 Hz	.30 g ² /Hz	at 4 dB above nominal
900 - 2000 Hz	- 12 dB/oct	22.7 g rms.

4.3.1.4 Pyrotechnic Shock

70 to 800 Hz	+ 12 dB/octave	One pulse in each direction
800 to 4000 Hz	1000 g peak	for three mutually perpendicular
4000 to 10,000 Hz	- 6 dB/octave	axes (total of 6 shocks).

4.3.1.5 Bench Handling Shock

Test consists of placing the test article, in its assembly and servicing stand, on a wooden bench top at least 1 5/8" thick and performing the following per MIL STD 810B, Method 516.1 Procedure V:

With the stand resting on its base lift one edge of the base four inches and allow the unit to drop back freely to the horizontal bench top. Repeat using the other three edges as pivot points for a total of four drops.

4.3.1.6 Acoustic

Test per MIL STD 810B, Method 515 Procedure I at nominal overall sound pressure level of 161 dB for 80 seconds plus 10 seconds at 4 dB above nominal. These levels apply to top face of instrument with the sides exposed to a level 6 dB lower.

4.3.1.4 Pyrotechnic Shock

70 to	800 Hz	+	12 dB/octave	One pulse in each direction for three mutually perpendicular axes (total of 6 shocks).
800 to	4000 Hz		1000 g peak	
4000 to	10,000 Hz	-	6 dB/octave	

4.3.1.5 Bench Handling Shock

Test consists of placing the test article, in its assembly and servicing stand, on a wooden bench top at least 1 5/8" thick and performing the following per MIL STD 810B, Method 516.1 Procedure V:

With the stand resting on its base lift one edge of the base four inches and allow the unit to drop back freely to the horizontal bench top. Repeat using the other three edges as pivot points for a total of four drops.

4.3.1.6 Acoustic

Test per MIL STD 810B, Method 515 Procedure I at nominal overall sound pressure level of 161 dB for 80 seconds plus 10 seconds at 4 dB above nominal. These levels apply to top face of instrument with the sides exposed to a level 6 dB lower.

4.3.1.7 Humidity

The humidity test was conducted as per MIL STD 810B, Method 507, Procedure I, except that the minimum temperature was 68°F and the maximum temperature was 120°F. This test was repeated for five cycles only.

4.3.1.8 EMC

Tests were performed in accordance with NR specifications MH04-02057-234 and IRN 9395.

Test Method	Freq Range	Spec Limits
<u>Conducted Interference</u>		
Oscilloscope	0 Hz - 15 KHz	0.8 V P-P
Current Probe	0 Hz - 25 MHz	--
<u>Radiated Interference</u>		
Rod Antenna	15 KHz - 25 MHz	--
Dipole Antenna	25 MHz - 1000 MHz	--
Directive Antenna	1000 MHz - 10,000 MHz	--
<u>Conducted Susceptibility</u>		
RF	50 KHz - 400 MHz	100,000 μ V
Audio	20 Hz - 50 KHz	--
50 V Transient	10 PPS - 2 Min.	+50 V Peak
0.5 V Transient	10 PPS - 2 Min.	\pm 0.5 V Peak

Radiated Susceptibility

Rod Antenna	0.14 - 20 MHz	1.0 V/M
Biconical Antenna	20 - 200 MHz	1.0 V/M
Conical Log Spiral Antenna	200 - 10,000 MHz	1.0 V/M except as follows
	250 - 300 MHz	2 V/M
	2270 - 2290 MHz	15 V/M
	9800 - 9850 MHz	7 V/M

Induced Field Susceptibility

Equipment	400 Hz	10 Amp. thru 5 Ft. of wire
Cabling	400 Hz	40 Amp. Feet

4.3.1.9 Minimum Useful Life (Analysis)

<u>Requirement</u>	<u>Results</u>	<u>Comments</u>
200 Operating Hours with the exception of the detectors	2000 Hr Min on Piece Parts and Components	Part Life Determined by Test and Similarity; Component Life Determined by Similarity

4.3.1.10 Storage (Analysis)

<u>Requirement</u>	<u>Results</u>	<u>Comments</u>
Two years	No Material Were Found to have Storage Life Affecting End Item Func- tion or Servicability in Two Years or Less.	All Materials Used Have Generic or Demonstrated Storage Life in Excess of Two Years Except Detectors which are Purchased 6 Months before Launch.

MANNED SPACECRAFT CENTER CERTIFICATION
TEST REVIEW SHEET

LOG NO. 08-001 FLT. P/N SEC 39106 425-305PART NAME Electron-Proton Spectrometer TEST P/N SEC 39106 425-301TEST COMPLETION DATE 3-8-72QUAL PLAN DOC. NO LEC EPS 503

DOCUMENTS REVIEWED _____

Qual. Test Report LEC EPS 695

Certification Documentation EPS 779

VEHICLE APPLICABILITY

CSM			ORB. ASSY			
116	117	118	ATM	MDA	AM	WS
X	X	X				

Anything other than unlimited approval will require explanatory remarks identifying the required action to attain unlimited approval.

REVIEW ITEM	APPROVED			DISAPPROVED	
	UN-LIMITED	ADD DATA	LIMITED EFF	ADD DATA	ADD TEST
1. CERTIFICATION REQUIREMENTS	X				
2. <u>DOCUMENTATION</u>	X				
A. TEST REPORT		X			
B. ANALYSIS REPORTS					
3. TEST ARTICLE CONFIGURATION	X				
<input checked="" type="checkbox"/> IDENTICAL WITH FLIGHT HARDWARE <input type="checkbox"/> DIFFERS FROM FLIGHT HARDWARE (ITEMIZED ON PAGE 2) <input type="checkbox"/> N/A					
4. CERT RELATED WAIVERS APPROVED: <u>NONE</u> QUANTITY (ITEMIZE ON PAGE 2)					
5. IS THIS ITEM CERTIFIED FOR EVA USE?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO			
IS THIS ITEM CERTIFIED FOR RE-ENTRY IN CH?	<input type="checkbox"/> YES	<input checked="" type="checkbox"/> NO			

Except as indicated by disapproved items above, the design of the equipment is considered satisfactory to perform its intended mission.

R.E. Perry 6-8-72
TBC R&QA/SSE DATE

Andrew J. Perry 6-8-72
NASA SSM/TEST COORDINATOR

DATE

Mark J. Lee 6/12/72
NASA REL. DIVISION DATE
GFE ENG'G BRANCH/NB5

JANUARY '72

John R. Hook 6/12/72
NASA REL. DIVISION DATE
CERTIFICATION BRANCH/NB4

MANNED SPACECRAFT CENTER CERTIFICATION REVIEW SHEET

08-001

LOG NO. _____

ACTION REQUIRED:

EIS 3.2.1.1.1 and 3.2.1.1.2 ICD is being revised by NR. ICD must be made available to verify the envelope after NR has revised the ICD.

EIS 3.1.1.1A, 3.1.1.1B, 3.1.1.1G and 3.1.1.1F - The detector data is not available for review and subsequent certification.

ADDITIONAL DOCUMENTATION:

ADDITIONAL TEST:

COMMENTS:

NR has not revised the ICD to reflect the approved interface requirement ECP has been approved by MSC and NR must now change the ICD accordingly.

The detectors have successfully passed all qualification testing to the required environments. Additional development testing to determine expected operational life, expected life, calibration curves etc., is required. An EAR (Engineering Analysis Report) of the development tests is required for certification of the detector.

4.4 Acceptance Test Unit Summary

Functional Test	Verify operation of significant system parameters.
-----------------	--

Thermal Cycling	Assurance that all workmanship defects are not existant.
-----------------	--

4.4.1 Acceptance Test Program

4.4.1.1 Function Test includes:

Power

Heaters

Electronics

Detector Bias

Housekeeping Parameter Checkout

Detector Leakage Current Monitor

Detector Resolution Monitor

Scientific Data Checkout

4.4.1.2 Thermal Cycle

Perform 1-1/2 thermal cycles between 38.9°C and -16.7°C

Dwell 2-1/2 hours minimum at each extreme and perform functional tests (total 3 tests).

4.5 Integrated Test Summary

<u>Type of Test</u>	<u>Results</u>	<u>Comments</u>
Integrated Test on SC 116 at NR.	System failed; however, enough data was taken to verify acceptable system performance	Engineering test model used. Failure caused by capacitor breakdown in power supply. Capacitor had been overstressed in earlier misapplication of voltage.

4.6 Special Test Summary

Detector Screen and Burn-In

Detector screening will encompass all testing performed on the detectors when they are received.

Detector Calibration

A series of calibration tests will be performed to provide data needed to prepare and confirm the analytic response functions

Detector Storage

Detectors which survive the burn-in will be placed in long term storage until needed.

Detector Thickness

Each detector requires a set of measurements to determine the nuclear thickness of its sensitive volume in order to permit the calculation of its sensor's energy response function. In effect, the thickness measurements permit calculation of correction factors necessary to be applied to the energy response functions determined on other detectors.

NOTE:

Detector calibration has been completed except for data analysis, other special tests will be performed on each detector purchased for flight to assure optimum performance during mission.

4.6.1 Special Test Program

4.6.1.1 Detector Screen & Burn-In

- Visual

The detectors will be mounted individually and examined under magnification for broken or loose silicon elements, loose or broken leads, bent mounts, or any other visually observable defect which might impair performance.

- Thermal

Detectors which pass the visual tests will be mounted on a plate and subjected to a thermal cycle over their anticipated environmental range in order to flex the mounting bond, the silicon cube, and the electrical contacts.

- Vibration

The detectors will be subjected to anticipated vibration levels for their projected use, in order to ascertain the integrity of the bond between the silicon cube and its mount.

- Leakage

The leakage current of each detector will be measured at specified temperatures.

4.6.1.1 Detector Screen & Burn-In (Continued)

- Response and Noise Tests

The response of the detectors will be measured, utilizing appropriate conversion electron sources, such as Cesium-137 and Bismuth-207. Also, a pulser will be fed into the electronic system, yielding information on the detector noise.

- Short Term Burn-In

Short term burn-in tests will be performed over a period of approximately 30 days. The detectors will be subjected to their full operating bias during this time, and the leakage, noise tests and response tests will be performed five times during the 30 days.

Continuous operation of the detectors for 30 days should eliminate the detectors of poor quality, and also provide data toward the determination of failure rates.

4.6.1.2 Detector Calibration

Low Energy Proton Calibration

The low energy proton calibration measurements will be made with a cyclotron such as the one at Texas A&M University. This machine has a maximum energy capability of about 60 MeV and is adjustable so that the required lower energies can be supplied.

High Energy Proton Calibration

The high energy proton calibration measurements will be made with a cyclotron such as the one at Harvard University. The Harvard Cyclotron has a fixed energy of 160 MeV, but the beam can be degraded to provide lower energies. The beam energy can be satisfactorily degraded enough to overlap with the energies available from the Texas A&M Cyclotron, but because of the energy broadening, cannot be satisfactorily degraded enough to cover the entire energy range of the EPS.

Electron Calibration

The electron detection efficiencies will be measured as a function of energy and angle over the sensitive range of the instrument. Since the electron channels are all integral discriminators with a relatively low discrimination level (200-300 keV), the detector response function will not be as sensitive to the incident direction as the proton channels. Also, the much greater scattering of the electrons in the shields reduces the effect of the shape of the detector itself on the angular response. The computer programs are not suitable for calculating energy loss by electrons, hence the primary emphasis will be placed on experimental calibration.

The electron response function of each type sensor will be determined by data at the calculated threshold level, the calculated effective level, and four higher levels. For each energy, angular data at four angles (0° , 45° , 67.5° and 90°) will be taken and should adequately determine the angular response.

4.6.1.3 Detector Storage

Upon completion of the screen and burn-in testing the detectors will be kept under bias, and the leakage and noise tests will be performed weekly. The response tests will be performed approximately monthly. Detectors passing this extended testing will be used for installation into the flight spectrometer.

4.6.1.4 Detector Thickness

All of the detectors which would be used in a flight instrument will be measured by penetrating each detector with a proton beam normal to a surface in each of three orthogonal directions. The known proton energy and measured energy disposition in the detector will permit the determination of the detector thickness.

5.0 PROBLEMS

5.1 Major Problems

5.1.1 Vibration Failure

Problem: When subjecting the structural test unit to the random vibration testing the screws and bushings holding the baseplate to the electronics package failed.

Corrective Action: An intensive investigation of the design approach was undertaken. To provide additional data, the failed test article was repaired and subjected to the sinusoidal resonant search. It became clear that the P/C boards would be subjected to levels of vibration that would seriously reduce the confidence level in their operating satisfactorily after vibration. Hence, an alternative approach was instigated, investigating the possibility of utilizing vibration isolators to reduce the vibration levels seen by the instrument. It was decided that isolators would be mounted within the basic envelope of the package, and that the outer housing and mounting flange would remain 'hard-mounted' with the electronics package mounted to this structure via the vibration isolators. The resultant arrangement is shown in Figure 5-1.

Verification of Corrective Action: A modified development test unit was subjected to the required random vibration criteria. The unit satisfactorily completed testing.

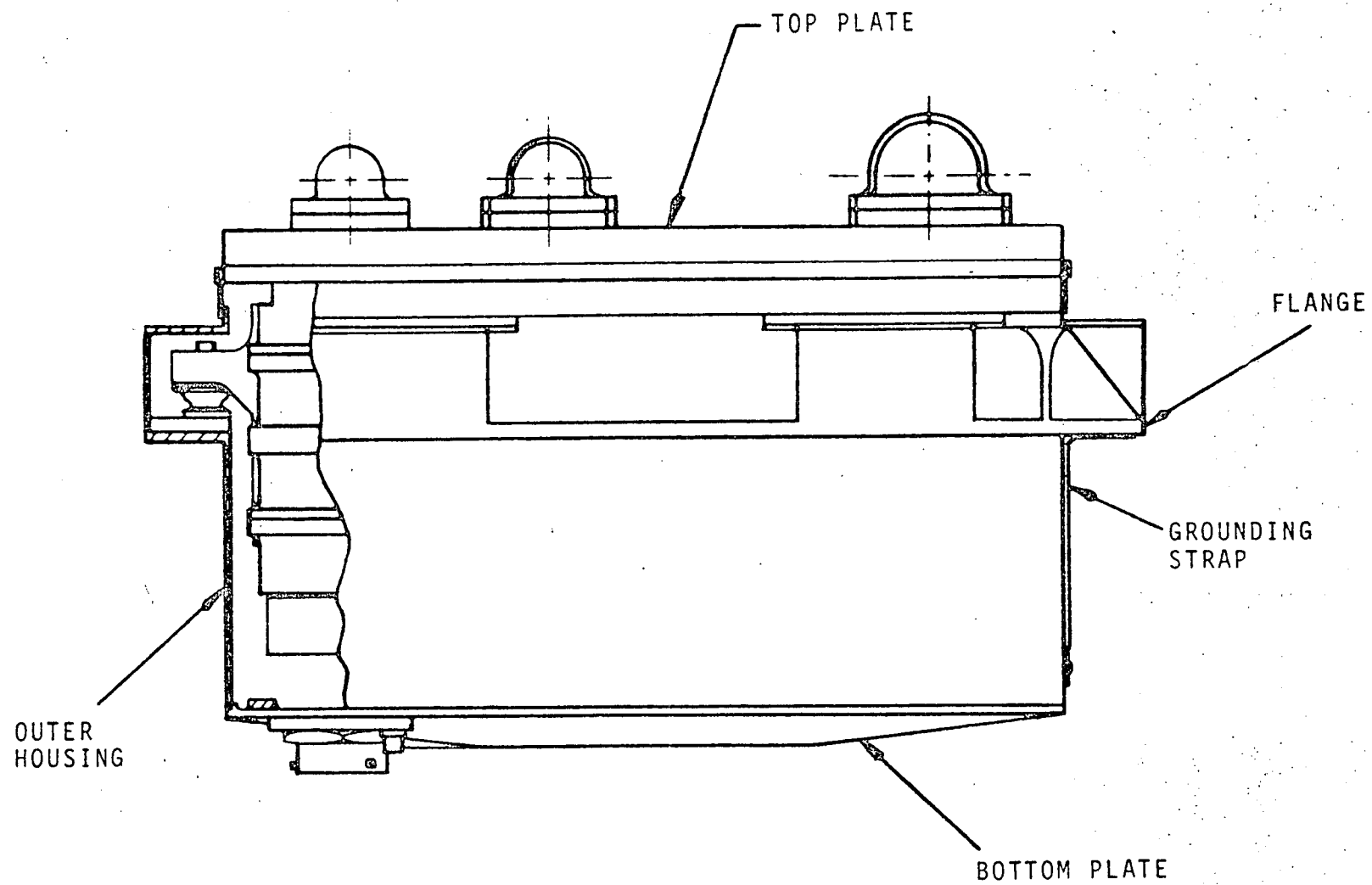


Figure 5-1. Diagram of EPS

5.1.1 Vibration Failure (Continued)

Conclusion:

The revised design provides a solution to the vibration problem that will allow the electronics package to be qualified to the vibration levels imposed.

5.1.2 Integrated Circuits

Problem: Contamination of Texas Instruments SN-54L-series logic as identified by Alerts MSC-71-04 and MSFC-71-21.

Corrective Action: In accordance with reliability recommendations as approved by the Skylab Program Office, all 54L-series logic were screened by NR Autonetics. To accomplish this screening required the purchase of additional logic to replace those parts used in the Qualification Test Unit and some other partially fabricated modules.

5.2 Minor Problems

<u>Component</u>	<u>Failure</u>	<u>Corrective Action</u>
FIAR EPS-0008 Mounting Straps	Unplated areas where shock mounting straps are attached were corroded.	Apply chemical film to all exposed metal surfaces per MIL-C-5541 Type I or II, Grade 6 Type 1
DR EPS-0130 Inner Electronics	Package and plate temperature read -50°C instead of 26°C.	Two pins on connector of tempera- ture monitor subassembly were tied to signal ground. These pins were disconnected and the system performed satisfactorily.
DR EPS-0115 PHD Subassembly	Electronic Discrimi- nator Threshold out of spec. at -25 and 0°C.	Integrated circuit failed during first thermal cycle and was found to have excessive drift of offset bias voltage or cur- rent. Part was replaced.
DR EPS-0113 Preamplifier Slice Assy.	Heli-coil inserts backed out.	Remove inserts. Clean and retap holes then install new inserts.

5.2 Minor Problems (Continued)

<u>Component</u>	<u>Failure</u>	<u>Corrective Action</u>
DR EPS-0106 Preamplifier Printed Wiring Board	Lead soldered to both sides of board without off pad soldering.	Replace component with lead soldered to pad on one side of board and lead bent and soldered approximately 1/4" from pad on other side of board.
DR EPS-0033 Detector Bias Supply	Bifurcated terminals soldered to both sides of printed wiring boards and are roll swaged.	Terminals removed and reinstalled by "V" swage and soldering to one side of the board.

5.3 Discrepanceis

Initial inspection of completed printed wiring boards required correction of the following:

- Components not mounted flush with pc boards.
- Unsoldered joints.
- Wiring errors.
- Broken leads.
- Excessive solder.
- Fractured solder joints.
- Dewetting
- Improper wire bends.

6.0 CRITICAL ITEM SUMMARY

The EPS, as a system, is considered a criticality III item. On the basis of this there are no category I or II failure modes.

7.0 SPECIFICATION VERIFICATION COMPLIANCE

7.1 Applicable Spec.

Spec.

Applicability

Waiver

MSC-KA-D-69-44

As specified in EIS

None

Rev. A

Rev. A

AAP Ancillary

Hardware General

Requirements

End Item Spec.

Applicable

None

for

Electron/Proton

Spectrometer

Rev. A Feb. 15, 1972

7.2 Specification Requirements Verified by Analysis:

Minimum Useful Life

Storage

Fungus Resistance

Single Point Failures

Structural Safety Factor

Parts and Material Selection

7.3 Specification Requirements Verified by Inspection:

Maintainability

Human Engineering

Weight and Size

Electrical Connectors-Keying

Wire Splicing

Wire Bundle and Harness Protection

Cleanliness

Workmanship

Identification and Marking

Safety Hazards

8.0 HARDWARE ACCEPTANCE SUMMARY

8.0 HARDWARE ACCEPTANCE SUMMARY

<u>Flight Unit Serial No.</u>	<u>Location</u>	<u>Status</u>
1002	Kennedy Space Center	8/2 Delivery to KSC is available for installation into S/C 116 (SL-2).
1003	North American Rockwell Downey, Calif.	8/2 Delivery to NR is available for installation into S/C 118 for integrated test.

CONTRACTOR READINESS STATEMENT

Electron-Proton Spectrometer, P/N SEC39106425-307
S/N 1002 Readiness Statement

Lockheed Electronics Company Houston Aerospace Systems Division representatives have assessed the readiness of the Electron-Proton Spectrometer as of 5-22-72 based upon applicable NASA specifications and NASA requirements and upon reviews conducted in accordance with the current, applicable NASA CARR Plan, and have determined this item to be in a condition of readiness for acceptance with the exception of the open items included in the ADP.

B. E. Curtsinger
Engineering - B. E. Curtsinger

5-31-72
Date

P. Gleeson
Reliability and Quality Assurance -
P. Gleeson

5-31-72
Date

B. C. Hall
Program Manager - B. C. Hall

5-31-72
Date

CONTRACTOR READINESS STATEMENT

Electron-Proton Spectrometer, P/N SEC39106425-307
S/N 1003 Readiness Statement

Lockheed Electronics Company Houston Aerospace Systems Division representatives have assessed the readiness of the Electron-Proton Spectrometer, P/N SEC39106425-307, S/N 1003 as of 7-17-72 based upon applicable NASA specifications and NASA requirements and upon reviews conducted in accordance with the current, applicable NASA CARR Plan, and have determined this item to be in a condition of readiness for acceptance with the exception of the open items included in the ADP.

Lockheed Electronics Company certifies that the above referenced Electron-Proton Spectrometer is identical in configuration and fabrication as the Electron-Proton Spectrometer Flight Unit No. 1 P/N SEC39106425-307, S/N 1002 which was delivered to NASA/MSC on 6/8/72.

B. E. Curtsinger
Engineering - B. E. Curtsinger

7/17/72
Date

P. Gleeson
Reliability and Quality Assurance -
P. Gleeson

7/17/72
Date

B. C. Hall
Program Manager - B. C. Hall

7/17/72
Date

NASA READINESS STATEMENT

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best available copy.

Electron/Proton Spectrometer

Readiness Statement

(Deliverable End Item)

P/N SEC39106425-307

The NASA-MSC technical monitor, the MSC Reliability and Quality Assurance Office and the Skylab Program Office representative have assessed the data submittal for the CARR of the Electron/Proton Spectrometer S/N 1003 (end item)

and certifies it is complete, has undergone all required tests, and is ready for flight use in accordance with the requirements of the CEI specification. Specifically this certifies that:

- a. Test sections of CEI specifications were prepared in accordance with the requirements of the contract requirements.
- b. Tests including qualification through manufacturing checkout, have been completed and have successfully demonstrated that the hardware conforms to the specification requirements.
- c. Critical hardware failures have been analyzed and corrected.
- d. Flight hardware has been manufactured, inspected and tested in accordance with the approved quality control program.
- e. Data for operation and checkout is complete, compatible and accompanies the hardware.
- f. Exceptions to the above are identified in a, open items identified in the data package, and b, the following open risks.

J. A. Zill
Skylab Program Office Representative

7/14/72
Date

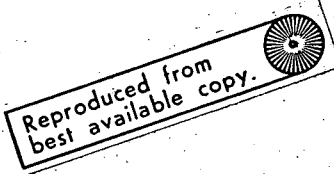
Carlton J. Forbes
NASA-MSC Technical Monitor

7/14/72
Date

Mark T. Lee
NASA-MSC Reliability and Quality Assurance

7/14/72
Date

NASA READINESS STATEMENT



Electron-Proton Spectrometer, Serial # 1002
(Deliverable End Item)
P/N SEC 39106425-307

Readiness Statement

The NASA-NSC Technical Monitor, the NSC Reliability and Quality Assurance Office and the Skylab Program Office representative have assured the data submitted for the CARR of the Electron-Proton Spectrometer, Serial # 1002 (End Item) and certify it is complete, has undergone all required tests, and is ready for flight use in accordance with the requirements of the CEI specification. Specifically this certifies that:


- a. Test sections of CEI specifications were prepared in accordance with the requirements of the contract requirements.
- b. Tests, including qualification through manufacturing check-out, have been completed and have successfully demonstrated that the hardware conforms to the specifications requirements.
- c. Critical hardware failures have been analyzed and corrected.
- d. Flight hardware has been manufactured, inspected and tested in accordance with the approved quality control program.
- e. Data for operation and checkout are complete, compatible and accompany the hardware.
- f. Exceptions to items a through e are identified as follows:

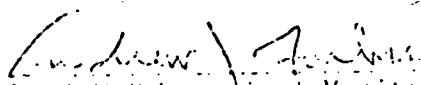
(1) The following open RID's:

CARR RID R-1, Availability of Handling/Installation Procedure

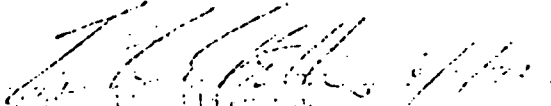
CDR RID D-01, Temperature Environment

CDR RID T-13, SM Pairing/E/RS Seal Integrity


Skylab Program Office Representative


NASA-NSC Technical Monitor

Date


Reliability and
Quality Assurance

9.0 OPEN ITEM SUMMARY

9.1 Open End Item Deliveries

<u>Flight Unit Serial No.</u>	<u>Location</u>	<u>Status</u>
1001	At Vendor	Qual Unit being refurbished into spare. Scheduled for completion Sept. 30, 1972.
1004	At Vendor	In assembly. Scheduled for delivery Sept. 15, 1972.
BTE (Test Set)	At Vendor	Being used to test flight hardware. Scheduled for delivery Oct. 1, 1972.

DETECTOR DELIVERY

<u>Launch</u>	<u>Delivery</u>	<u>Comment</u>
SL2	Dec. 1972	Procurement for detectors to be finalized with manufacturer by Oct. 1, 1972. Each launch will be supported by approx. 20 detectors. Deliveries are scheduled 5 months before present launch dates.
SL3	Mar. 1973	
SL4	June 1973	

9.2 Open Design Problems:

None.

9.3 Incomplete Qual Activities

None.

9.4 Open Failure Analysis

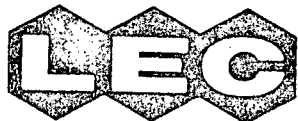
None.

9.5 Open Work

Spectrometer Installation: A flight spectrometer with dummy detectors will be installed on each spacecraft at KSC before the start of combined systems test (TCP 0070)

Detector Installation: Detectors will be installed into the flight spectrometer just prior to CDDT. These detectors will be selected on the basis of special test as defined in para. 4.6.1.1, 4.6.1.3 and 4.6.1.4.

10.0 CERTIFICATION OF DESIGN



ELECTRON/PROTON SPECTROMETER

CHART NO. 13

DATE _____

SPEAKER A. J. Farkas

The design of the Electron/Proton Spectrometer is hereby certified as meeting all of the scientific objectives and requirements set forth in the applicable specifications and provisions of Contract NAS 9-11373 and is capable of supporting the Skylab manned mission, contingent upon resolution of the list of open items.

B. C. Hall
LEC Program Manager

M. L. Raines, Director of
Safety, Reliability, and
Quality Assurance

A. J. Farkas
MSC Technical Monitor

K. S. Kleinknecht, Manager
Skylab Program Office

M. A. Faget, Director of
Engineering and Development